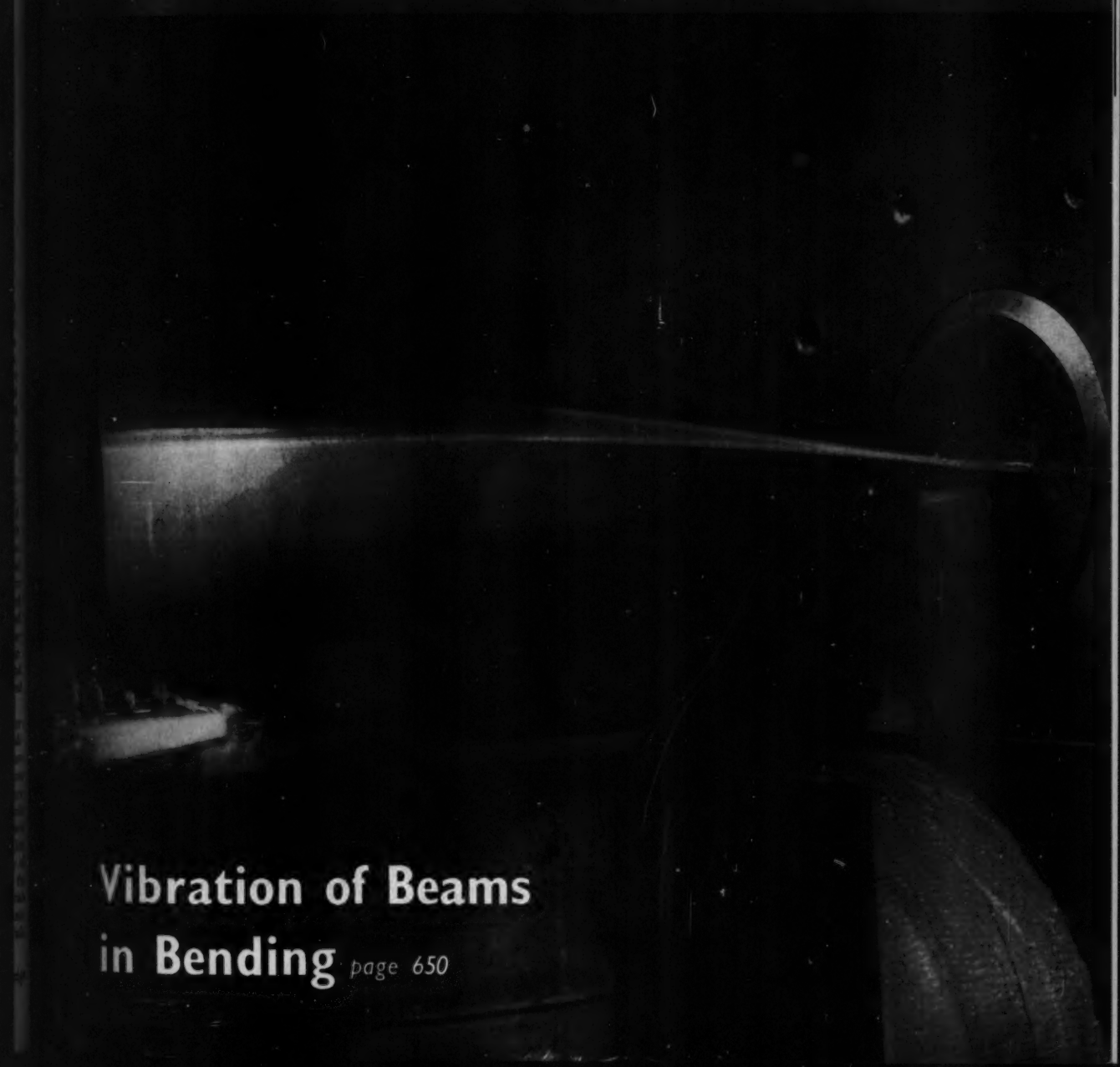
Engineering Materials and Design



Vibration of Beams in Bending page 650

EMD 7541 for further information

OSBORN

EXTRUDED STEEL SECTIONS

Cut Costs

Extruded steel sections are produced in most qualities of steel, including carbon and alloy steels, stainless steels and special alloys.

Hundreds of different shapes have already been extruded, ranging from simple angles to most complex shapes. Physical properties are identical with similar rolled sections and extrusions can be supplied in random lengths of 8 ft to 30 ft, with dimensional tolerances to suit requirements.

Send for further details of Osborn extruded steel sections and take the first step to lower costs by reduction in machining and elimination of scrap.

SAMUEL OSBORN & CO. LIMITED

CLYDE STEEL WORKS, SHEFFIELD

Steelmakers · Steelfounders · Engineers' Toolmakers

Engineering Materials and Design

★ *The Magazine for Engineering Designers*

A HEYWOOD PUBLICATION

Vol. 4 No. 10 October 1961

MANAGING EDITOR
H. R. Heap, B.Sc., A.M.I.E.E.

EDITOR
R. D. Cullum, M.I.E.D., A.R.Ae.S., M.I.A.S.

ASSISTANT EDITORS
F. R. Terrell
J. B. Howson

Metal blade being subjected to controlled vibration in a test rig at Battersea College of Technology.

Published monthly by HEYWOOD & COMPANY LTD., Drury House, Russell Street, London, W.C.2 (Tel.: TEMple Bar 3422), on the 20th of the preceding month. Annual subscription 35s. sterling per annum ($5.25, U.S.A. and Canada) throughout the world. Single copies to order from all newsagents and bookstalls, 2s. 6d. each (by post from the publishers, 3s. 0d. each). BRANCH OFFICES: Royal Buildings, 2 Mosley Street, Manchester, 2. Tel.: Central 9935 Bayliss House, Hurst Street, Birmingham, Tel.: Midland 5786; 52 St. Enoch Square, Glasgow. Tel.: City 3492; 527 Madison Avenue, New York, 22, N.Y., Tel.: Plaza 9-1171.

© Heywood & Company Ltd., 1961. Must not be reproduced without written permission.

ISSUE AT A GLANCE

page

VIBRATION OF BEAMS IN BENDING 650

Describing the Rayleigh equations for calculating the fundamental frequency of bending vibration of a heavy beam.

By **Dr. W. Carnegie**

HEAT-TREATABLE TITANIUM SHEET ALLOYS 658

Comparison of two high-strength beta titanium alloys.

By **D. Goold**

SURVEY OF PIPE COUPLINGS: PART 3 660

Concluding the survey, and dealing with couplings for plastics pipes, glass pipes, and flexible, swivel and rotating joints.

By **A. H. Roach**

DESIGN OF VISUAL INDICATORS: PART 2 672

Discussing the design of qualitative moving-scale indicators, and also summarising the aspects dealt with in Part 1.

By **John Spencer**

OTHER FEATURES

New Solar Power Device 676

Data Sheet No. 68: Cobalt-base Super-alloys 687

Data Sheet No. 69: High-alloy Steels for Investment Castings ... 689

Review of Design Courses 690

New Ideas from Farnborough 693

Metal-bonded Graphite 697

Brass Plating of Titanium 698

REGULAR FEATURES

Materials in the News ... 639
Picture News 640
Leader 649
Letters to the Editor 654
Problems in Design 655
New Ideas in Design 669
Overseas Newsletter 679
New Books 683
New Materials 701
New Components 705
New Equipment 711
New Office Equipment ... 713
New Publications 713
News of Industry 715

CLASSIFIED ADVERTISEMENTS ... ... facing page 646

Résumés

ETUDE DES RACCORDS DE TUYAUX: 3ème partie

par A. H. Roach page 660

Cet article conclut l'étude et traite des types suivants de raccords: flexibles, joints pivotants et rotatifs, accouplements pour tuyaux en verre.

DESSIN DES INDICATEURS VISUELS: 2ème partie

par John Spencer page 672

Dans ce second et dernier article sur ce sujet, l'auteur examine le dessin d'indicateurs quantitatifs à échelle mobile et résume les divers aspects étudiés dans la première partie.

DEVELOPPEMENT D'ALLIAGES DE TITANE EN FEUILLE TRAITABLE A LA CHALEUR

par D. Goold page 658

L'auteur compare deux alliages de titane béta de grande résistance: B120 VCA (fabriqué par Crucible Steel Co. d'Amérique) et EXO11 (fabriqué par Imperial Chemical Industries).

VIBRATION DES POUTRES LORSQU'ELLES SE COURBENT

par le Dr. W. Carnegie page 650

L'auteur décrit les équations Rayleigh utilisées pour le calcul de la fréquence fondamentale des vibrations de courbure d'une grosse poutre sans charge concentrée. Il donne également des équations de fréquence dans le cas d'une lourde poutre portant un certain nombre de charges concentrées.

Kurzreferate

ÜBERSICHT ÜBER ROHRVERSCHLÜSSE: Teil 3

A. H. Roach Seite 660

Dieser Teil beschliesst die Übersicht und befasst sich mit den folgenden Arten von Rohrverschlüssen: flexible, drehbare und rotierende Verbindungen; Verbindungen für Glasrohre.

KONSTRUKTION VON SICHTANZEIGERN: Teil 2

John Spencer Seite 672

In diesem zweiten, abschliessenden Teil des Artikels bespricht der Verfasser die Konstruktion von quantitativen Anzeigern mit beweglicher Skala und fasst die Kennzüge des ersten Teils zusammen.

DIE ENTWICKLUNG VON VERGÜTBAREN TITANBLECHLEGIERUNGEN

D. Goold Seite 658

Der Verfasser vergleicht zwei hochfeste Beta-Titan-Legierungen: B120 VCA (ein Erzeugnis der Crucible Steel Co. of America) und EXO11 (ein Erzeugnis der Imperial Chemical Industries).

VIBRATION VON BALKEN BEI BIEGUNG

Dr. W. Carnegie Seite 650

Die Rayleigh'sche Gleichung zur Bestimmung der Grundfrequenz der Biegeschwingungen eines schweren Balken ohne konzentrierte Belastung wird besprochen. Der Artikel bringt auch Frequenzgleichungen für einen eine Anzahl konzentrierter Lasten tragenden schweren Balken.

Резюме

СБЗОР ТРУБНЫХ СОЕДИНЕНИЙ: ЧАСТЬ 3

А. Г. Роуч Стр. 660

Заключительная часть, в которой описываются следующие виды трубных соединений: гибкие, поворотные и вращающиеся муфты, а также муфты для стеклянных труб.

КОНСТРУКЦИЯ ВИЗУАЛЬНЫХ ИНДИКАТОРОВ: ЧАСТЬ 2

Джон Спенсер Стр. 672

Во второй и последней части этой статьи автор обсуждает конструкцию количественных индикаторов с движущейся шкалой и резюмирует вопросы, освещенные в 1-ой части.

РАЗВИТИЕ ЛИСТОВЫХ СПЛАВОВ ТИТАНА, ПРИГОДНЫХ ДЛЯ ТЕРМИЧЕСКОЙ ОБРАБОТКИ

Д. Гулд Стр. 658

Автор сравнивает два высокопрочных сплава бета-титана — B120 VCA (изготовитель — «Крусибл Стил Компани», США) и EXO11 (изготовитель — «Империэл Кеминэл Индастриз»).

ВИБРАЦИЯ БАЛОК ПРИ СГИБАНИИ

Д-р У. Карнеги Стр. 650

Описываются уравнения Рэлея для вычисления основной частоты сгибательной вибрации тяжелых балок без концентрированных нагрузок. Уравнения частоты также даются для тяжелых балок, несущих несколько концентрированных нагрузок.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Engineering News

ON THURSDAY, October 5 a new engineering weekly, *Engineering News*, is to make its first appearance. It is of increasing importance that all people connected with engineering, whether in a design capacity or an administrative, commercial or financial post, should be properly informed of current world-wide developments in industry. Only in this way can industry thrive financially and technically. Most people in industry have little time to spend in reading news which is not of direct interest to them—*Engineering News* is designed to provide information in a form easily and quickly digested.

Engineering News will be published by Heywood & Co. Ltd. at 4d. per copy from newsagents (in case of difficulty write to the publishers), and will be complementary to *Engineering Materials and Design*, which will continue to provide technical information and data for those with design responsibilities, as well as keeping others associated with engineering well informed on the latest research and technical developments.

Designers taking both *Engineering News* and *Engineering Materials and Design* will be assured of being kept right up to date not only on technical matters, but also on the related commercial, administrative and financial aspects.

Diamond Impregnation for Anti-seizure Surfaces

AN UNDERSTANDING of the nature of friction and wear and consequently their control has become more important as the design of mechanisms during the past two decades has come to be associated with a rapid increase in environment severity and in demand for reliability. Severe operating conditions have resulted in the development and extensive use of the so-called dry lubricants, such as molybdenum disulphide (MoS_2) and graphite, and extreme pressure additives which increase the load-carrying capacity of conventional fluid lubricants. Both techniques rely on separating the sliding surfaces by an easily sheared layer. Another method of allowing relative sliding under severe conditions involves the use of very hard surfaces, such as tungsten carbide or stellite, which resist wear and abrasion but which may be associated with high coefficients of friction, for example $\mu=1$. The extreme hardness of diamond is well known, and its friction coefficient is 0.05 in the unlubricated condition.

Recent tests carried out at Bradford Institute of Technology by James Wells, and presented in a paper at the Institute of Mechanical Engineers, examined a method of transferring the excellent friction and wear characteristics of diamond to sliding surfaces by impregnating such surfaces with a very large number of diamond particles. Proving tests are described which examined the load-carrying capacity and wear behaviour of impregnated surfaces when lubricated with aviation paraffin or synthetic oil. A comparison was made with surfaces sprayed with molybdenum disulphide and polytetrafluorethylene (p.t.f.e.), and various other impregnating media.

Particles of a hard material, for example diamond, were impregnated into the sliding surface, the projecting sharp edges being subsequently removed to leave numerous small pads above the surface. The experimental programme was limited mainly to bronze sliding on hardened steel, these being lubricated with aviation paraffin, but a few tests under conditions of high Hertz stress (hard steel sliding on hard steel) and synthetic oil lubrication showed similar beneficial effects. Only the hardened steel was impregnated in the bronze-on-steel tests. It was shown that silicon carbide is a suitable substitute for diamond, and that there appears to be an optimum size of particle for impregnation.

Endurance running of the impregnated surface (bronze on steel lubricated with fuel) at loads up to 300% of the failing load of a conventionally lapped surface was satisfactorily performed with coefficients of friction of the order of 0.001. Excellent repeatability of control tests was obtained.

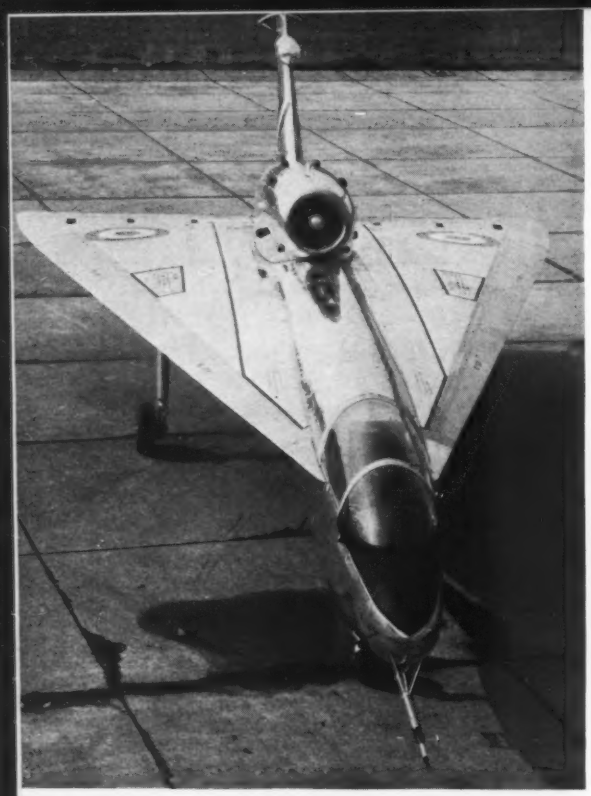
An industrial firm reports that one application of the process has been in a swash plate fuel pump which was fed with fuel contaminated with silica, of particle size 0-10μ to accelerate wear. Tests results showed that, far from increasing wear, the contaminated fuel reduced wear rate to some 50% of that associated with clean fuel. Subsequent examination of the sliding surfaces showed that the slipper pad tops and bowls were impregnated with the silica particles, which in turn had caused a hard polished surface resulting in very little wear.

At present the process is in a purely embryonic state, and the full possibilities and limitations remain to be explored. There is need for a more academic approach to the subject, but sufficient results have been obtained to confirm the significance of the process, although its application to industrial problems will require a great deal of further effort.

De-stressing Railway Tracks

THE EASTERN AND SOUTHERN REGIONS of British Railways have been successfully using specially designed air-propane gas burners for de-stressing continuously welded rails; it is claimed that this method is cheap and efficient. The burners, developed by The British Oxygen Company Ltd., warm the rail to between 18 and 24 deg. C. before it is fastened down. This enables the continuous rail to withstand the subsequent stresses of expansion and contraction in varying weather conditions.

The air-propane de-stressing unit consists of a trolley supporting four heating muffles each housing two burners which are fed from four 100-lb. propane cylinders. De-stressing is carried out by moving the trolley slowly along a section of track with the heating muffles directed against the continuously welded rail. The temperature rise is assessed by measuring the amount of expansion which takes place; for example, when the temperature of a 500-yard length of rail is raised from just over freezing point to 21 deg. C., it expands approximately 4 in.—this heating operation takes about 1½-1½ hr.



SUPERSONIC SHAPE

The Handley Page 115 research aircraft on show at Farnborough this year was built to help in the investigation of handling characteristics, stability and control of supersonic designs at low speeds. Its engine is a Bristol Siddeley Viper jet.

CARLONA CAMERA COVER

The cover for the Agilux autoflash camera is moulded by I.T. & M. Plastics Ltd. from Shell Chemical Co.'s Carlona P polypropylene, which provides a high resistance to abrasion with minimum weight.

PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN

STEEL CAP FOR ALUMINIUM PISTON

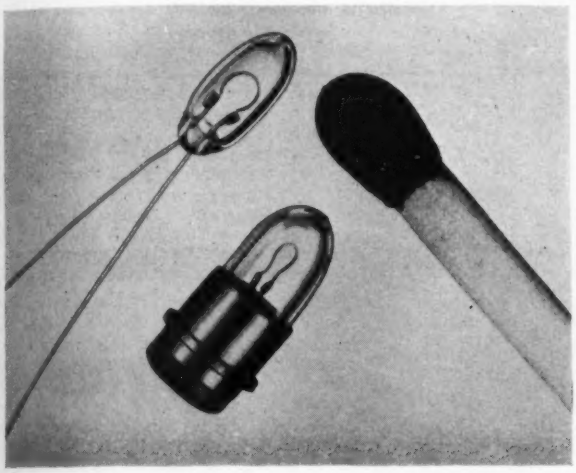
This aluminium piston is capped with a thin layer of stainless steel for experimental purposes. Designed and made by the Aluminium Company of America, it has been sectioned in order to study the pressure bond process, for which Alcoa hold basic patents.

FILIGREE STEEL JOISTS

Developed by Head Wrightson & Co., the machine shown below produces girders in three standard depths to BS Code of Practice CP 114. The completed girder is sent to flooring contractors who cast a vibrated concrete plank onto the lower girder chord. Hollow concrete slabs are used as an in-fill between girders.

ELECTRONIC CONTROL FOR DRILLING MACHINE

An electronically-controlled drilling machine equipped with a multi-spindle head has enabled a girl operator at General Electric Co.'s Telephone Works at Coventry to quadruple her output. Previously, altering a jig took up to 10 hr.; a new tape can now be made in 15 min.

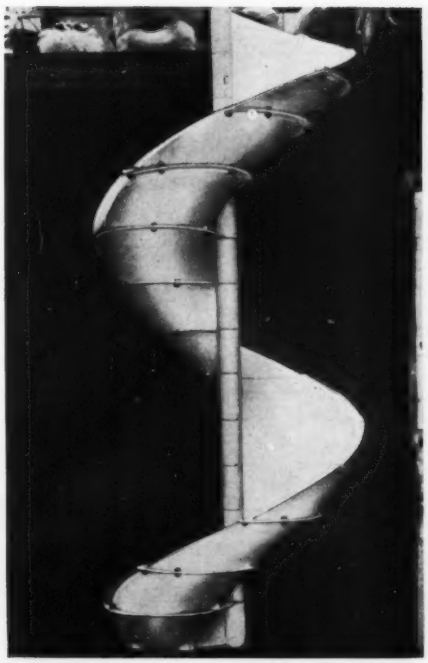


SUB-MINIATURE LAMPS

Capped and wire-ended versions of new 6-volt sub-miniature lamps are now available from Thorn Electrical Industries Ltd.; life expectancy is well over 10,000 hr. Above, their size is compared with a match head.

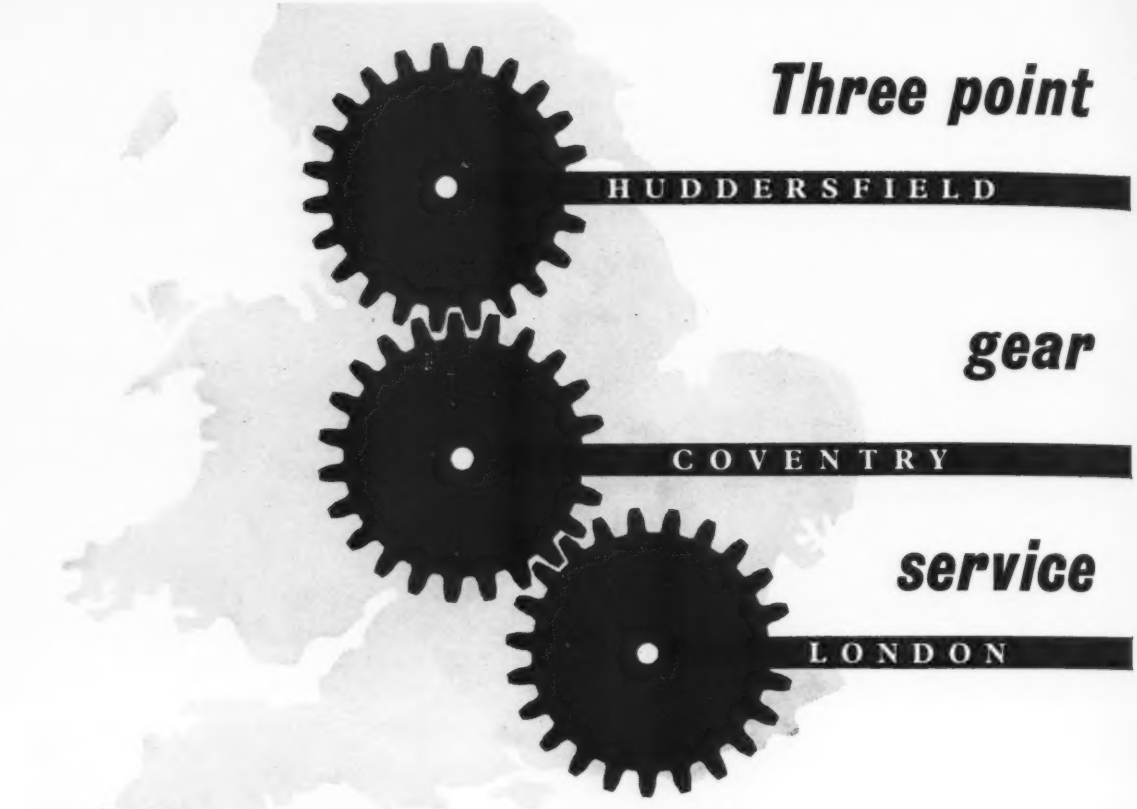
GLASS-FIBRE SACK CHUTE

A glass-fibre sack chute now being manufactured by Thomas Robinson & Son Ltd. will carry bags weighing up to 2½ cwt. It is claimed to be more rigid than metal chutes, as well as being lighter and easier to keep clean.



ATOMIC CENTIPEDE

On the left is shown the interior of one of the massive components of Hilac, a heavy ion linear accelerator used for chemical transmutation experiments. Garrett Corp., of the U.S.A., have been associated with the recent development of two such accelerators.



It's worth going to the other end of the country — to the other end of the world! — for David Brown gears. But happily you don't have to. In addition to their headquarters in Huddersfield, David Brown have factories in Coventry and London. Each of these Divisions offers a first class service in gear production. Whether you're nearest to Huddersfield, Coventry or London you get the benefit of the immense resources of the whole David Brown organisation. If you're not already a D.B. customer, get in touch with your nearest factory right away — and learn for yourself what they can do!

DAVID BROWN

100 YEARS SERVING INDUSTRY 1860-1960

An alliance of engineering specialists in gearing, machine tools, tools, castings, automobiles, and agricultural tractors and machinery.

THE DAVID BROWN CORPORATION (SALES) LIMITED

GEAR DIVISIONS
PARK WORKS, HUDDERSFIELD
Tel : Huddersfield 3500

COVENTRY GEAR DIVISION
BROOKLYN ROAD, FOLESHILL
Tel : Coventry 88004

LONDON GEAR DIVISION
STONEBRIDGE PARK WORKS, NORTH CIRCULAR RD., N.W.10. Tel: ELGar 6824

OA/6672B

Heavy-duty Gasket

INCREASINGLY SEVERE CONDITIONS in diesel engines have necessitated the development of special cylinder-head gasket materials. Among the more successful constructions is one of German origin called Reinz Repa, made by Reinz Dichtungs Gesellschaft, whose London agents are Chillcotts Ltd.

The gasket is supported by a woven steel wire mesh filled with an asbestos compound. A thin facing of synthetic rubber (of the neoprene type) on both surfaces completes the basic sheet construction. In fabricated gaskets the "eyeletting" round the periphery of holes is carried out in aluminium-coated steel sheet (to German Specification DIN 1624 st. 4, a dead-mild quality) the coating thickness being about 0.0005 in. The wire of DIN 177 quality (mild steel 26-32 tons u.t.s.) is 0.013 in. thick in the 1 mm. gasket. Weave is of the herringbone type with twenty-eight ends per inch warp and weft.

The properties of this gasket are remarkable mainly for the high recovery from compressive strain and good resistance to spread under load. Contact with hot oil or anti-freeze solution has little or no effect on the material.

This type of heavy-duty gasket is particularly valuable in wet-linered diesel engines, where the liner protrudes above the block face and the gasket is severely nipped between the liner edge and the head. Under the punishing conditions of diesel use, gaskets which spread or yield without adequate recovery are very liable to fail.

In fairness, however, it should be pointed out that some British-made gasket materials are capable of this duty. For instance Coopers Cemjo G 63, which employs a perforated mild-steel sheet as reinforcement, with an asbestos/butyl rubber composition facing, has properties similar to Reinz Repa.

Friction Welding Machine

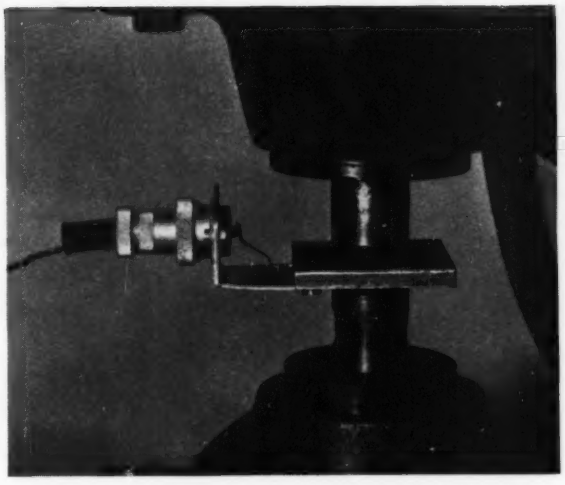
A DEMONSTRATION of friction welding was one of the most interesting demonstrations given at the recent opening of the new engineering laboratory for the British Welding Research Association. In the past this technique has been more fully exploited by both the U.S.S.R. and the United States, and it was particularly interesting to see the approach made by the B.W.R.A. The machine was designed and made by the staff, and while cost, manufacturing facilities and time available to some extent dictated the design, it was influenced by the need for instrumentation with respect to existing recording equipment.

The machine has an approximate maximum welding capacity of 1 sq. in. in mild steel, and is powered by a standard 10 h.p. motor with a speed of 950 r.p.m. The axial force is provided by a 12-in. dia. double-acting air cylinder which, with a 100 p.s.i. air line, provides upset and friction forces to a maximum of 5 tons. The drive is by a positive grip belt and stepped pulleys, allowing speeds of 430, 640, 800 and 1,200 r.p.m. to be selected quickly and at a relatively low constructional cost.

The major mechanical problem involved is that of arresting the revolving head, and doing this by means of a clutch, or by reversing the phases of the power supply to the motor, or by capacitor injection, would have been costly and would have added several months to the construction time. An alternative which has been adopted in this design is to allow the stationary shaft to accelerate up to the speed of the decelerating driven shaft, which may also be further decelerated by a solenoid-operated brake.

Release of the stationary spindle is accomplished by means of a simple torque arm on the non-driven shaft, the arm being held against rotation by a pivoted cantilever which in future experiments will carry strain gauges to enable the torque to be recorded. The cantilever is held in the stop position by a solenoid-operated latch, the solenoid being energised automatically at any pre-determined "burn off" distance as measured on the specimens.

The solenoid control circuit also trips the motor and operates the air valves, allowing the maximum force of the air cylinder to be applied to the work piece. A simple beam is interposed between the cylinder push rod and the moving work head, to carry strain gauges to record friction and upset forces.



An alumina thermocouple is shown mounted horizontally between two sheets being welded.

Spot Weld Temperatures

ALTHOUGH SPOT WELDING is used extensively for joining sheet-metal components, little is generally understood of the way in which spot welds are formed. The process tends to remain more of a craft than a science, although it can be accurately controlled and readily automated.

When spot-welding hardenable steels, the use of a simple weld pulse gives rise to joints which are brittle, and post-weld heat-treatment is necessary to make the weld ductile: this is usually done in the machine on the basis of trial and error. The British Welding Research Association is currently concerned with measuring the temperature cycle during spot welding by means of alumina thermocouples mounted either vertically inside the electrode or horizontally between the two sheets being welded. Very fine wire thermocouples are needed to follow the rapid changes in temperature during the welding cycle, and the output is recorded on a high-speed ultra-violet galvanometer recorded or displayed on an oscilloscope.

Some idea of the temperatures involved is indicated by the fact that alumina thermocouples can be melted inside the weld, indicating a peak temperature of at least 2,000 deg. C.

Powder Metallurgy in the U.S.S.R.

ACCORDING TO a recent Russian report the strength of sintered iron parts may be increased by alloying with phosphorus. During sintering, a liquid phase forms which, as in the sintering of iron with copper, increases the sintering capacity of the powder. During sintering at 590 deg. C., the phosphorus is dissolved in the iron, and an alloy of iron with a high phosphorus content and a melting point of 565 deg. C. develops on the surface of the powder. Though phosphorus is regarded as a harmful mixture in traditional metallurgy it helps to produce a special structure of relatively high strength and elongation. With a 0.7 to 0.8% mixture of phosphorus, strengths of 31.75 t.s.i. have already been obtained, the addition of more phosphorus somewhat increasing the shrinkage. A steel without the mixtures of phosphorus, and with a tensile strength of 14.0 t.s.i. and relative elongation of 6%, has been improved to 21.0 t.s.i. and 8% elongation, and 33.0 t.s.i. and 12% elongation, by the addition of 0.3 and 0.7% respectively of phosphorus.

The report also adds that not only iron and steel, but also aluminium, magnesium and their alloys are being more and more widely used in the production of machine parts by the powder metallurgy method. In addition to aluminium powder, aluminium fibres have lately been used, permitting strength to be substantially increased without changing the porosity. The fibres pulverised in the liquid are fed into a closed porous form where they settle on the inner walls and are flattened out. They are then taken out, dried and sintered.

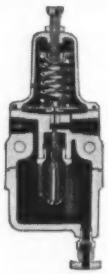
INDUSTRY WELCOMES THE NEW TECALEMIT RIBBON FILTER ELEMENTS

Setting a fresh standard of high efficiency filtration for

AIR—WATER—PETROL DIESEL AND FUEL OILS | LUBRICATING, HYDRAULIC AND OTHER FLUIDS

Chosen for the famous FISHER small volume regulators

Tecalemit Ribbon Filter Element is used in the series 67 combination Filter Regulator, manufactured by Fisher Governor Company Limited of Rochester. In such an application, the paper ribbon filter allows air to flow freely and provide adequate filtration, and water separation. A Tecalemit ribbon filter is sufficiently robust to withstand pressure drops well in excess of normal working conditions.



Tecalemit Ribbon Filter Elements

Simple construction—Low cost—High flow rate—Easy to clean

The elements are formed to resin impregnated cellulose ribbon, wound helically and electrically fused into an open-ended cylinder. Innumerable microscopic orifices between the ribbons allow a very high flow rate, while retaining impurities on the outside or inside surfaces, according to direction of flow. The standard range of diameters (in any length) covers most applications, and no other filtration material can so readily be adapted to individual requirements for filters, strainers, breathers or separators. Never before has such fine filtration been possible at such low cost and with such flexibility in use.

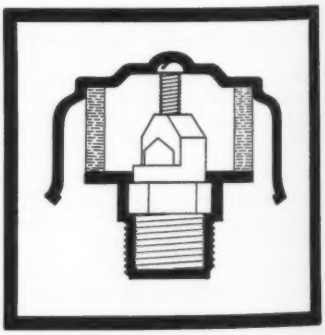
Tecalemit Ribbon Elements filter to maximum purity

Tecalemit Air Breather Filters

(Incorporating Tecalemit Ribbon Filter Elements)

Cheapest—most efficient—cleanest to service Tecalemit Breathers act as ventilators to provide a free flow of clean air to hydraulic fluid, fuel and oil reservoirs. They give positive protection from airborne contamination to tanks, pumps, valves, cylinder and other engine components. Of the standard types, two are breathers with screwed bodies, and the third is a combined clip-on assembly of breather and filter cap. All are fitted with Tecalemit Ribbon Filter Elements.

Tecalemit Breathers provide pure air cheaply and efficiently



TECALEMIT the authority on filtration

TECALEMIT LIMITED · (SALES EMD) · PLYMOUTH · DEVON

T. 711

The Productograph

THE PRODUCTOGRAPH, for which Adrema Ltd. have the marketing and assembly rights in the U.K. (from Siemens-Halske, Germany), is an advanced system for the recording and writing of data from individual operating units in a production process.

Essentially, information is gained from transducers fitted on such equipment as individual machine tools, and packaging and continuous production machinery. The transducer converts the information into an electrical signal, which is then fed to the Productograph control centre, which may deal with 20, 40, 60, 100 or 200 transducer sources of information.

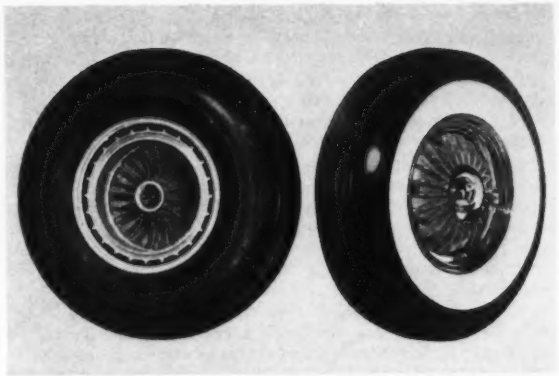
The control centre consists of: a linear counter for the visual production recording of each unit in the factory; the electrical counters, which record the quantity of product produced and the production time consumed; the integrator for group control, which indicates by a light system the productive and idle times of plant units; the machine diagram recorder, which records continuously the production cycles of up to twenty machines per recording unit on twenty double tracks on the high-speed recorder for the extended work analysis of any particular production unit; the Duplex and light signalling installation for control lights at plant stations, and for two-way communication between the operator and control; and the tape recording system for the recording of instructions and explanations.

Aluminium Wheels

FROM THE RESULTS of a series of tests on integral aluminium wheels and brake drums, Kaiser Aluminium and Chemical Corp. suggest that strong lightweight wheels with brakes not subjected to fading will be the next major application of aluminium in automobiles. Brake fade is dangerous because the average motorist is unaware of its presence, and does not adjust his driving technique to it when circumstances create critical braking conditions. Although disc brakes provide an answer to the problem of fade, the braking advantage of the integral aluminium wheel is achieved by the ability of aluminium to quickly dissipate heat.

Combining the wheel, hub and brake drum into an integral casting is a practical design that can compete costwise with existing steel wheels. The balancing of individual components is eliminated, the entire casting acts as a heat sink, and the integral construction is inherently stronger and lighter than the equivalent assembly of separate components.

Following dynamometer tests, three 70 m.p.h. stops using conventional steel wheels produced noticeable fade; after six stops, more or less a complete loss of braking was experienced. In contrast, a car equipped with the aluminium wheels and drums on the front wheels only completed twenty-four successive stops before noticeable brake fade occurred in the rear steel wheels, and at no time was complete brake-loss experienced. The line pressure in these tests was 1,200 p.s.i. for the steel wheels, and 600 p.s.i. for the aluminium wheels.



It is most significant that the temperature on the standard steel production drums showed a constant increase throughout the tests, and reached 490 deg. C. in a series of consecutive stops with the temperature still rising. In contrast, the temperature in the aluminium wheel started to level off and remain at 220 deg. C., this being well below the temperature of 315 deg. C. which is recognised as that at which severe brake fade and lining wear begins.

Aircraft Controls for Submarines

AIRCRAFT SCIENCE has had the benefit of extensive research and development effort by many people for many years—there are several aspects of aircraft technology which may fruitfully be applied to submarines. Much has already been applied, particularly in hydrodynamics, which has drawn heavily from incompressible viscous aerodynamics, but progress implies our future submarines must go deeper and faster, and be highly manoeuverable. They must be manned by fewer personnel, and must have lighter internal structure and furnishings as their increased hull thicknesses cause them to become weight-limited. A significantly improved submarine will therefore require improvements in skin friction drag, propulsion systems and structures.

This expensive high-speed submarine of the future must have excellent controls, both manual and automatic. The potential application of aircraft techniques to controls was of primary concern of a recent paper given by Joseph D. Malloy (Republic Aviation Corp.) to the Institute of the Aerospace Sciences, of the U.S.A. Submarine dynamics is considered to be a prerequisite to the control problems, as a means of understanding the characteristics of submarines and as a field of application in itself.

Knowledge of submarine characteristics and their representation dynamically in mathematical form have been applied at the Republic Aviation Corp. in the design of automatic and manual control systems for modern submarines, and have been extrapolated into the future in terms of increased speed and depth in an attempt to predict future problems and needs.

Aircraft techniques and certain standard autopilot feed-back loops have been embodied in the design, including rate and attitude loops to alter the submarine dynamics, integral feedback terms to eliminate residual errors, and appropriate loops to compensate for cross coupling effects.

Tests have been performed on a modern high-speed submarine having an aircraft fighter-type control stick, which was used for normal manual operation with one man controlling both depth and course. Artificial feel is provided by trimmable feel capsules, and dynamic stick forces are provided by magnetic dampers. The feel trim control-button is at the top of the grip, and causes the neutral position of the stick-feel-force to shift. This permits the operator to hold a rudder angle or stern plane angle with no stick force, which is desirable under certain conditions. Other grip switches are available for control of inter-communication channels, and if desired ballast trim.

One-man control of combined manoeuvres has been performed satisfactorily using this control stick, and the next step is to establish the feasibility of using a miniaturised version for hand electric control. It would seem that the results of these tests are significant if the Navy's objective is to reduce the ship's complement, and also size and weight of components in future submarines.

THE NOVEMBER ISSUE

of *Engineering Materials and Design* will include the following main features:

Selecting Spring Fasteners
Two-part article written by members of two leading companies producing spring-type fasteners.

Temperature-indicating Melts, Paints and Crayons
Dealing mainly with methods of use, application procedure, readability, and assessment of errors.

Materials Selection in Design
Suggesting new methods of presentation for data on the properties of engineering materials.

Design with Copper-alloy Castings
Describing some of the interesting developments which have recently taken place in the bronze and brass founding industry.

Surface Flatness

UNTIL A FEW YEARS AGO the flatness of a component was rarely specified on a drawing except in specialised fields, it being implied that this was covered by the relevant dimensional tolerance. Even now, when the use of surface finish limits is becoming widespread, these unfortunately are seldom related to functional requirements.

The most usual reasons for surface finish and flatness limits on a component are where it is necessary to provide a leak-proof joint face. In all cases of metal-to-metal joints it is necessary to provide a finish that will not rapidly deteriorate as a result of wear, and that will enable the two faces to come close enough to each other to prevent the passage of gas or other media between them.

In many cases, the designer specifies the finish in micro-inches CLA, and assumes that this will ensure leak-proof mating of the faces. However, it is possible for plane errors of a relatively long wavelength, from say 0.25 in. upwards to exist, and not to be detected by the conventional surface finish measuring instruments which are designed to meet British Standard requirements in terms of cut-off lengths. In practice, this means that where leaks occur they are often attributed to inadequate surface finish, rather than to flatness irregularities.

In many cases experiments have proved that where the flatness of joint faces is improved it is possible to relax the surface finish requirements. Until recently, the accurate lapping of flat surfaces was considered a hand operation, which was a lengthy operation and required a considerable amount of skill.

The increasing demand for lapped surfaces on low-priced components has necessitated the design and manufacture of machines capable of equalling or surpassing the craftsmen's standards at low cost levels. A further requirement is that these machines should be capable of operation by unskilled or semi-skilled labour, and in many cases by women.

After considerable research into this problem, the Lapmaster has been designed. This machine, embodying a self-conditioning feature and manufactured by Payne Products International Ltd., of Slough, offers industry a method of generating surfaces of precision flatness and finish in short runs or in high production quantities—at a remarkably low production cost. With this unit a surface flatness of one light band (11.6 millionths of an inch) can be consistently held—on components of up to 6-8 in. dia.—and micro-inch finishes of from 6 to 8 CLA (or better if required) are common on a wide range of materials including steel, steel alloys, cast iron, bronze, quartz and other semiconductors, ceramics, plastics and tungsten carbides.

Its versatility also permits the loading and lapping of parts of dissimilar shapes and materials in one cycle—a time and cost saving feature.

Lapmasters are available in six standard sizes to meet every requirement, from laboratory or experimental operations up to production runs on large castings. For a limited number of specific components, a job-lapping service is offered.

Changing a worn lap plate on the 24-in. Lapmaster. Although the plate weighs 170 lb., this operation can be carried out by one man when using the Haltrac pulley system.

Fluteless Taps

ONE OF THE DIFFICULTIES encountered in tapping small holes is that conventional taps are weakened by the flutes necessary for egress of the swarf produced during the tapping operation. Fluteless taps represent a relatively new approach to the problem of producing female threads. They operate somewhat on the lines of thread rolls, whereby no material is removed but the metal is displaced and flows into the tap profile to form the thread. One of the advantages of this process is that the threads thus produced have a very favourable grain structure, and are therefore stronger than cut threads. Careful design of the tap lead encourages the flow of the metal in the most advantageous manner. Taps to this design were exhibited during the inaugural week of the new premises for the Alfred Herbert Applied Research Department, and enlargements of cross sections of screw profiles shown with these exhibits indicated the direction of grain flow. The surface finish of the thread profiles was also very good, owing to the burnishing action of the highly finished tap thread profiles.

Copper-bearing Steels

THE TWO OUTSTANDING ADVANTAGES of iron and steel for use in metal structures are strength and cheapness. It is always essential, however, that they be shielded from the atmosphere by a protective coating in order to reduce rusting to an economic level.

An obvious way of overcoming this problem of rusting is to make suitable alloying additions to the steel so that it will become stainless, but as this increases the initial cost some tenfold, it has to be considered in light of service requirements. If, on the other hand, an alloying addition could be found which would significantly reduce the rate of rusting of steel without appreciably increasing its cost, then a worthwhile step would have been taken. For many years it has been known and proved that the addition of 0.2-0.3% copper increases the cost of the steel by no more than 5%, and will extend the life of a structure by some 50-100%, whether it is bare, painted or galvanised.

In the majority of cases, however, designers and engineers do not consider the corrosion resistance of the structural steel selected for use, but specify steels according to their mechanical properties depending for corrosion resistance upon the protective coating subsequently applied. There is little doubt, however, that a very marked advantage both in reducing the frequency of repainting and cost of preliminary preparation is gained when copper-bearing steels are used. It is, therefore, up to the engineer to take advantage of these steels by specifying the presence of copper as an alloying element, a requirement which is catered for in the British Standards for structural steels (BS 15, 548 and 968).

Copper in the proportion required to improve the corrosion resistance (0.2-0.3%) has virtually no effect on the mechanical properties of the steel, which may be welded with the ease of mild steel, using the same technique, no special precautions being required.

The Copper Development Association will shortly be publishing a booklet which will include details of these significant structural materials.

ON BEING A "BOD"

A RECENT advertisement for drawing office capacity mentioned that a "50 board capacity" was available. The boards were presumably manned by 50 "bods." In other words, the services of fifty human beings, each having an immortal soul, trained to carry out drawing office work, were being offered for hire to carry out goodness knows what kinds of varied work. With the remorselessness of robots or zombies they would, for a fee, set to and carry out the work.

The wording of the advertisement is perhaps typical of the world we know today. Hard anxious brain-racking work is done by innumerable anonymous "bods." You and I are bods (this article carries no signature). Perhaps we shall read one day of hospitals having so many beds attended by so much "stethoscope capacity!"

To be a "person," with all the oddities of physical peculiarities, temperamental quirks, quaint abilities, etc., one must, it seems, have an understanding wife or husband, or kindly forgiving friends. But to the boss one is just a bod—that's all. The only ones among us who emerge from "bodhood" and are recognised are either pop singers, politicians, TV "Personalities," or people with enormous moustaches.

Much is talked and written about the "Team Spirit," rather too much emphasis being placed on leadership. Cattle must be driven from behind. Sheep are led from the front. With human beings engaged in technical work it is better for the leader to be in the midst of his men. Those who stand on their dignity do not gain in stature thereby. To do his work well the leader's human qualities must be, if anything, greater than his technical ones. He must, however, be respected for both kinds of quality.

It is not sufficiently recognised that leadership is as much a quality of those who are led as of the leader. To become a good member of a team requires much "recognition of one's own size," self discipline and loyalty-despite-abuse-from-above, that are every bit as hard to learn as the qualities expected of a leader. It frequently happens that so-called "natural leaders" are great boobies who, on account of their sheer physical size, slick verbiage or other irrelevant qualities happened to be noticed when the post was vacant. Some are great scoundrels. To work loyally under such as these calls for great qualities of self restraint, but to do so for any length of time is the mark of the coward or the fool.

In a design office the good chief is a friendly fellow. The nature of the work to be done makes the sergeant-major kind of discipline impossible, for he must be out to stimulate originality, not ensure conformity. He must therefore make people feel that they belong. He knows his job. He can, in the most friendly way, when he sees a layout he does not agree with, suggest a better way. But he does this in so modest a manner, but with such authority, that the draughtsman almost feels that he himself thought of the better idea proposed. The good chief does not pretend to knowledge he does not possess, and when floored by his subordinates with superior ideas to his own, carries respect as he defers. His skill should not lie in snubbing people, but rather in being able to deal candidly with both the brighter and not-so-bright members of his staff. If he does not, they will just leave him.

His manner should be as relaxed as his intellect is taut, and he should respect his fellow men. Only under such leadership can the grinding toil of preparing detailed technical schemes be carried out successfully.

Classified Advertisements

GLACIER METAL COMPANY LIMITED

Kirkstyle, Kilmarnock, Ayrshire

Research Engineer

A Research Engineer is required for the Metallurgy Department of our expanding Research and Development Organisation.

His primary concern will be the problem of fatigue failure in bearing materials and the development of materials and treatments designed to extend fatigue life.

He will be given the opportunity of pursuing his own lines of investigation, drawing upon the background of experience and the technical services and facilities available within the Company.

Applicants should have a Degree in Engineering (with a bias towards Metallurgy) or a Degree in Metallurgy (with a bias towards Engineering), coupled with a strong interest in and an aptitude for applying mathematical techniques. The preferred age range is 22-28 years, and some previous research experience would be an advantage.

Starting salary will probably be of the order of £1,000-£1,400, depending on qualifications and experience, and there are excellent prospects for further advancement.

Applications containing brief details of age, qualifications and experience, to Personnel Services Manager, quoting reference 3/RDO/12/128/E.M.D.

Design engineer available for mechanical design and detail work. Experienced in aircraft control systems and general precision engineering. Herts, Beds, Cambs area. Box No. E.M.D. 32.

Design detail and tracing capacity available by Competent Designers. Mechanical and aircraft experience. VANdyke 3548.

SERVICE

REED-MOORE PLASTIC FABRICATIONS COL 1072 42, Sidley Avenue, Victoria Avenue East, Blackley, Manchester, 9. Specialists in all types of Plastic Fabrication. (P.V.C. Polythene and Perspex Assemblies). E.G. Ducting, Louvres, Dye-baths, Dye-units, and Electrical Junction Boxes etc. Anything you require can be fabricated and welded thus saving the heavy cost of having to pay for metal moulds and formers. Enquiries will be appreciated and suggestions made if required.

STEP-DRILLS AND COUNTERBORES. Up to 1¼ in. diam. cut from stock sizes. Drills sharpened from 0.006 in. to 1¼ in. All types of points. DRILL SERVICE (Horley) Ltd., 89 Albert Road, Horley, Surrey. Tel. Horley 4406.

50,000 PRECISION INSTRUMENT GEARS OF ALL TYPES FROM STOCK! (NOW INCLUDING SPIRAL BEVELS).

Write for fully comprehensive Catalogue. The Davall Gear Company Limited, Potters Bar, Middlesex.

Telephone Number:
Potters Bar 57141—5 lines

3 lines 7s. 6d. (minimum), additional word 6d.—Box number 2s. extra.

For Box Numbers reply to ENGINEERING MATERIALS & DESIGN, Drury House, Russell Street, Drury Lane, London, W.C.2.

TO OVERSEAS DESIGN ENGINEERS AND EXECUTIVES

You can keep in touch with INTERNATIONAL developments in the selection and use of materials, components and finishes in engineering design by seeing this leading magazine every month

A subscription costs 35/- for one year, and only 70/- for 3 years.

Please send your order to our Agent in your country, or to HEYWOOD & COMPANY LTD., DRURY HOUSE, RUSSELL STREET, LONDON, W.C.2, ENGLAND.

ARGENTINE
Through Gordon & Gotch Ltd.
Librerias Mackern, Avenue de Leandro N. Alem, 457, Buenos Aires.
Mitchells Bookstore, 570 Cangello, Buenos Aires.

AUSTRALIA
Alberts Bookshop Pty. Ltd., 14-22 Forrest Place, Perth.
Angus & Robertson Ltd., 89-95 Castlereagh Street, Sydney, N.S.W.
Centre of Fashion Trade Journals, 100 Flinders Street, (Near Exhibition Street), Melbourne, C.1.
Engineering Publications (Aust.), 52 Pitt Street, Sydney, N.S.W.
H. A. Goddard (Pty.) Ltd., 255A George Street, Sydney, N.S.W.
The Grahame Book Co., 39-49 Martin Place, Sydney, N.S.W.
John Hinton & Co., 50 Miller Street, North Sydney, N.S.W.
Jervis Manton (Pty.) Ltd., 190 Bourke Street, Melbourne, C.1.
J. W. Martin (Pty.) Ltd., Box H561, G.P.O., Perth.
Messrs. Swain & Co. (Pty.) Ltd., Pitt Street, Sydney, New South Wales.
The Tait Book Co. Ltd., 349 Collins Street, Melbourne, C.1, Victoria.
The Technical Book & Magazine Co., 295-299 Swanston Street, (opp. Old Melbourne Hospital), Melbourne, C.1, Victoria.
H. C. Walker, Rich & Co., Grand United Buildings, 149 Castlereagh Street, Sydney, N.S.W.
Through Gordon & Gotch Ltd.
Gordon & Gotch (A'sia) Ltd., 80 Currie Street, Adelaide.
Gordon & Gotch (A'sia) Ltd., G.P.O. Box 1462 T., 262/264 Adelaide Street, Brisbane, Queensland.
Gordon & Gotch (A'sia) Ltd., 511/515 Little Collins Street, Melbourne, C.1, Victoria.
Gordon & Gotch (A'sia) Ltd., 134-144 Parry Street, Perth.
Gordon & Gotch (A'sia) Ltd., G.P.O. Box 1627 B.B., Barrack and Clarence Streets, Sydney, N.S.W.

AUSTRIA
Through Continental Publishers & Distributors Ltd.
Messrs. Morawa & Co., Wollzeile 11, Vienna, 1.

BAHAMAS
Through Gordon & Gotch Ltd.
Moseley's Ltd., P.O. Box 434, Nassau.

BELGIUM
Dohmen Freres, 237 Rue Royale Sainte Marie, Brussels 111 (Schaerbeek).

BRAZIL
Livraria Stark Ltd., Caixa Postal 2786, Sao Paulo.
Through Gordon & Gotch Ltd.
Casa Crashley Ltda., 58, Ouvidor, Caixa Postal 906, Rio de Janeiro.
Publicidade Exletica, S.A., Box 539, Sao Paulo.

BRITISH GUIANA
Mr. Oswald Bentham, General Supplies Agency, Commission Merchants, P.O. Box 375, Georgetown.

BRITISH WEST INDIES
Messrs. Smith & Alfred, 4 Bellsmythe Street, Woodbrook, Port-of-Spain, Trinidad.
Through Gordon & Gotch Ltd.
Stephens & Todd Ltd., 8 Frederick Street, Port-of-Spain, Trinidad.

BURMA
Continental & Overseas Indentors, Post Box 1163, Rangoon.

CANADA
Mr. G. Bray, The Bray Circulation & Advertising, Post Office Box No. 788, Station B, Montreal, P.Q.
The Davis Circulation Agency, Oakville, Ontario.
Wm. Dawson Subscription Service Ltd., 587 Mount Pleasant Road, Toronto, 12, Ontario.
"Periodica", 5090 Ave., Papineau, Montreal 34.

CEYLON
Mr. M. C. C. Wickramanayake, Director, The City Stores Ltd., 48 Ward Street, Kandy.
Through Gordon & Gotch Ltd.
W. E. Bastian & Co., 23 Canal Row, P.O. Box 10, Colombo.
Colombo Apothecaries' Co. Ltd., P.O. Box 31, Price Street, Fort, Colombo.
Plate Ltd., P.O. Box 127, Colombo.

CHILE
Marjan Sucheston, K. Casilla, No. 9950, Santiago.

COLOMBIA
Libreria "El Gato Negro", Carrera 7A, 14-35, Oficinas 201 Y 206, Bogota.

CYPRUS
The Union Trading Co., 41, 41a Zinonos Kitieos Street, P.O. Box 123, Larnaca.
Through Gordon & Gotch Ltd.
S. Ch. Papadopoulos, 88 Ledra Street, Nicosia.

CZECHOSLOVAKIA
Artia Ltd., Ve Smeckach, 30, Praha, 11.

DENMARK
Aksel J. Nielsen, Osterbrogade, 84, Copenhagen O.
Store Nordiske Videnska Bokhandel, Ronersgade 27, Copenhagen.
John Poulsen, The Illustrated News Service, Dahlerupsgade, 1, Copenhagen V.
C. A. Reitzels Bokhandel, Axel Sandal, Norregade 20, Copenhagen.
Victor Schroder, Esq., Hovedvagtsgade, 8, Copenhagen, K.
Th. Wessel & Vett Ltd., Norregade 7, Copenhagen.

ECUADOR
Messrs. "Bravos", Publications Agency, Guayaquil.

EGYPT
Librairie Hachette, 45 bis Rue Champollion, Cairo, Egypt.
Librairie Hachette, 61 Rue Nabi Daniel, Alexandria, Egypt.
Librairie La Renaissance D'Egypte, Messrs. Hassan & Yousef Mohamed & Co., 9 Sh. Adly, Cairo, Egypt.
The New Publications, Joseph Meshaka & Co., 49 Saad Zaghloul Street, Alexandria, Egypt.
The New Publications, Joseph Meshaka & Co., 3 Maspero Street, Cairo, Egypt.

FINLAND
Akateeminen Kirkjakauppa, 2, Keskaskatu, Helsinki.
Rautatiekirjakauppa O/Y, Helsinki.

FRANCE
Arthur Reins, 4 Square Moncey, Paris 9e.

GERMANY
W. E. Saarbach G.m.b.H., Gertrudenstrasse 30, Koln, 1.
Wm. Dawson & Sons, G.m.b.H., Klosterstrasse 34-36a, Dusseldorf.

GREECE
G. Hagiantoniou, 31 Rue Du Stade, Athens, Greece.

HOLLAND
G. De Vries, Lindenlaan, 10, Zaandijk.

HONG KONG
M. H. Shamdasani & Co., 90B Nathan Road, Kowloon, Hong Kong.
Through Gordon & Gotch Ltd.
The Harris Book Co., 10 Ice House, Street, Kowloon, Hong Kong.

ICELAND
Hilmar Foss, P.O. Box 154, Reykjavik.

INDIA
C. G. Beard, 49 Gulstaun Mansions, Park Street, Calcutta.
Khurana Advertising and Publicity Service, 6 The Mall, Agra.
Mahajan Brothers, Opp. Khadia Police Gate, Ahmedabad.
"Manufacturers" Eastern Agency, P.O. Box 301, Bombay.
B. Muni Ratnam, Muny's Subscription Agency, P.B. No. 1653, Madras, 1.
The New Order Book Co., Ellis Bridge, Ahmedabad.
L. V. Paramesh, Mandavali Lane, Mylapore, Madras, 4.
The Popular Book Depot, Grant Road, Bombay, 7.
Mr. B. L. Shah, Magazines Department, Messrs. Charles Lambert & Co., P.O. Box 4087, Bombay, 7.
D. B. Taraporevala Sons & Co., Ltd., "Treasure House of Book", 210 Hornby Road, Fort, Bombay.
The Technical Book Depot, Forjet Terrace, Tordeo, Bombay, 26.
Through Gordon & Gotch Ltd.
Central News Agency, 19/20 Connaught Circus, New Delhi.
New Photoplay Co., 231 Hornby Road, P.O. Box 61, Bombay.
Oxford Book & Stationery Co., Park Street, Calcutta.

IRAN
Through Gordon & Gotch Ltd.
Alfi's Stationery Shop, Avenue Zand, Abadan.

IRAQ
The Empire Trading Co., Khediry Road, Ashar, Basrah.
The Iraq Bookshop, 436A/1 Rashid Street, South Gate, Baghdad.
Through Gordon & Gotch Ltd.
Abdullah Farjo's Bookshop, Ashar, Basrah.

ISRAEL
The Central Subscription Agency, 3, Ben-Yehuda Street, Jerusalem.
Mr. H. Weiss, Weiss' Subscriptions, 22, Allenby Road, Tel Aviv, Israel.

ITALY
Bruno Bollini, Via Verdi, Empoli.
Ulrico Hoepli, Corso Matteotti, 12, Milano.
Interscientia, Corso Garibaldi 34, Venaria, Piemonte.
Editoriale "Maggiora", Piazza 18, Dicembre, 1, Torino 116.
C. Ruggeri & Co., Via Verziere, 2, Milan.
Sperling & Kupfer, Piazza S. Banila, Galleria Metteotti, Milano.
Guido Spiriti, Piazza Risorgimento 10, Milan.

JAPAN
F. Fujita, 586 Kita Senzoku, Otaku, Tokyo.
Fukumatsu Funahashi & Co., No. 11 4-Chome, Kawaramachi, Higashiku, Osaka.
Marusho & Co. Ltd., c/o Messrs. Toyolite & Co. Ltd., 5, 5-chome, Kitonagasa-dori, Ikutaku, Kobe.
Kaigai Shuppan Boeki K.K., 21 Kanda Tsukasacho 2-Chome, Chiyoda-Ku, Tokyo.
Maruzen Co. Ltd., 6 Tori-Nichome Nohonbashi, Tokyo.

JORDAN
Guiseppe Gedeone, Star Street, Bethlehem.

KENYA
Anglo-Tanganyikan News Agency Ltd., P.O. Box 6784, Nairobi.
Jadavji Valji & Sons, P.O. Box 506, Nairobi.
Through Gordon & Gotch Ltd.
East African Standard Ltd., P.O. Box 380, Nairobi.
S. J. Moore Ltd., Government Road, Nairobi.
Nzoia Press Ltd., P.O. Box 34, Kitale
Superior Printing Works, P.O. Box 181, Salin Road, Mombasa.
Warners Bookshop, P.O. Box 36, Nakuru.

LEBANON
Dimitri K. Haddad, P.O. Box 786, Beyrouth.
Elias Andraos Haddad & Freres, P.O. Box 265, Beyrouth.
Gureghian Freres Immeuble-Stephan Rue Fakhreddine, Beyrouth.
J. M. Saad, P.O. Box 352, Beirut.

MALAYA
Davies & Co., Room 22, Bank of China Building, Singapore, 1.
Fongs Trading Co., P.O. Box 220, Singapore.
M. H. Shamdasani & Co., 43 The Arcade, Singapore.
Through Gordon & Gotch Ltd.
Asia Books Co., 91 Brewster Road, Ipoh, Perak.
S. A. Azeez Bros., Railway Station Bookstall, Klang.
The Jubilee Store, 1 and 1a Gladstone Road, Penang.
R. Kandasamy, Railway Station Bookstall, Port Swettenham, Selangar.
Kedah Bookstore, 79 Julan Langgar Alor Star.
Lim Chye Hock, 45 Station Road, P.O. Box 27, Taiping, Perak.
E. K. Yeap & Co., 20 Brewster Road, Ipoh.

MALTA. G.C.
Cachia & Co., 4 St. Anthony Street, Valletta.
Through Continental Publishers & Distributors Ltd.
Sapienza's Library, 26 Kingsway, Valletta.

MAURITIUS
Ebrahim Dawood, Dawood Building, 1 Louis Pasteur Street, P.O. Box 27, Port Louis.
The Mercantile Service Bureau, P.O. Box 262, Port Louis.
The Eastern Trading Co., Quay Square, Port Louis.

MEXICO
Sr. Emilio Minon, Apartado 2209, Ave. Arquimedes No. 91, Mexico D.F.

MOROCCO
International Press Agency, P.O. Box 182, Tangier.

NEW ZEALAND
N. Hamilton-Baker, G.P.O. 721, Wellington.
Messrs. R. Hill & Son, Cnr. Crowhurst and Kent Streets, Auckland, S.E.1.
Technical Books, Ltd., P.O. Box 6318, Wellington.
Gordon & Gotch (N.Z.) Ltd., Lincfield Street, Christchurch.
Gordon & Gotch (N.Z.) Ltd., Jamieson Buildings, Dunedin.

NORWAY
Contact Publishing Co. A.S., Akeragt 59, Oslo.
Narvesens Litteratur Tjeneste, P.O. Box 115, Oslo.
Norsk Bokimport A.S., Edv. Stormagt 1, Oslo.
Trygave Juul Moller (Bokhandel), Fr. Nansens Plass, 8, Oslo.

NYASALAND
Through Gordon & Gotch Ltd.
Blantyre Printing & Publishing Co., P.O. Box 6, Blantyre.

PAKISTAN
Ideal Subscription Agency, 42 The Mall, Lahore.
N. A. Mukhtar & Co., Sukkur, Sind.
Scafar Agencies, Grindlays Bank, Bunder Road, Karachi, 2.

PORTUGAL
Valentim Lourenco, Rua de o Seculo 34-3, o, Lisbon.
A. Vicente Ribeiro, Avenida da Liberdade 236-1°-E, Lisbon.
Through Continental Publishers & Distributors Ltd.
Livraria Bertrand, 73 Rua Garrat 75, Apartado N. 78, Lisbon.

SOUTH AFRICA
British Technical Journals, 15 Baines House, Broad Street, Durban.
Lindex (South Africa) Pty. Ltd., P.O. Box 4536, Johannesburg.
Central News Agency Ltd., 58 Maidland Street, Bloemfontein, Orange Free State.
Central News Agency Ltd., P.O. Box 599, 60/62 Oxford Street, East London, Cape Province.
Central News Agency Ltd., P.O. Box 356, 16 Adderley Street, Port Elizabeth, Cape Province.
Central News Agency Ltd., 86 Visagie Street, Pretoria, Transvaal.

SOUTHERN RHODESIA
Messrs. Felix Sutherland (Rhodesia) Ltd., 20 Orr Street, Salisbury.
Mr. V. W. Van Rijnberk, P.O. Box 238, Bulawayo.
Kingstons Ltd., P.O. Box 256, Cnr. Fife Street and Sixth Avenue, Bulawayo.
Kingstons Ltd., 89 Victoria Street, Salisbury.

SPAIN
J. Diaz de Santos, Libreria J. Diaz de Santos, Calle Lagasca 38, Madrid.

SUDAN
Through Gordon & Gotch Ltd.
The Sudan Bookshop, P.O. Box 156 Khartoum.

SWEDEN
J. Ekelund, Knislinge.
Stig. Falk, Vallingatan, 13, Stockholm, 1.
A. B. Nordiska Kompaniet, Hamngatan 18-20, Stockholm, 7.
A. B. Siowalls Bokhandel, Drottninggatan 86, Stockholm.
Wennergren-Williams, A. B., Fack, Stockholm, 30.

SWITZERLAND
Mr. Willi Hardi Grossistch No. 100 571, Ober-Muhen.
W. Frey-Schneeberger, Mattenweg 13, Lenzburg.

SYRIA
Vahan Darakjian 291, Atfaiych St. Aleppo, Syria.

TANGANYIKA
Through Gordon & Gotch Ltd.
Arusha Bookshop, P.O. Box 240 Arusha.

THAILAND
Teck Heng & Co., 1326 New Road, Bangkok.
The Sales Agency Co., 1091/1093 New Road, Bangkok.

TUNISIA
Maison Allal, Allal Emma, 18 rue Durand-Claye, Tunis.

TURKEY
Bedros Kapman, P.O. Box 2158, Istanbul.

URUGUAY
Kurt Palnitzsky, Casilla Correo 293, Montevideo.
R. Raphael, Convencion 1488, Montevideo.

U.S.A.
The Overseas Publishers' Representatives, 29 West 34th Street, New York, N.Y., U.S.A.

DESIGNING FOR THE COMMON MARKET

THE creation of a common market, which involves the gradual elimination of tariffs, quotas and other obstacles to trade between member countries means that the common commercial business terms used by companies extending their overseas operations are likely to become increasingly familiar to the British engineer and designer.

The impact on British industries is difficut to predict in detail; we shall no longer enjoy the preferences of the Commonwealth but will have to face the stark reality of direct competition with other nations and countries.

Although it is possible to estimate where opportunities will be greatest, the way in which industries will be affected in the long run will depend on how they react. The scale of production becomes more important as trade barriers are removed. In consumer goods, where trade is likely to increase most, Britain has some of the largest manufacturing units in Europe—vacuum cleaners and medium-size cars are good examples. Nevertheless, this is not a situation which allows room for complacency. Success in the Common Market demands vigorous attention to production, scrapping of uneconomical activities, and rapid and flexible adjustment to meet a changing pattern of demand.

The designer is a key figure; generally, a product is born in the design office, and whatever modification it may receive during production and testing, its basic character remains either good or bad.

Success in the export field and the maintenance of a happy relationship with overseas customers depends not only on successful marketing policies, but also on being able to adequately satisfy many technical requirements. These include the adherence to standards laid down by the country to which the goods are exported, and are similar to our BS Specifications.

For large volume mass production, standardization must be considered as a possible solution to economic production. The special requirements of overseas customers should as far as practicable be incorporated in the standard model, the alternative approach of designing for the home market and modifying the design to meet the needs of export countries at a later stage being more costly and less efficient. National habits in the use of an appliance vary from one country to another and these must be investigated.

Considerable thought must be given to the selection of materials; metal finishes must be specified and closely controlled. If electrolytic corrosion under humid conditions is to be obviated. contact between certain different metals or plated finishes must be avoided. Packaging used for export must have strength to prevent damage, and be able to resist the ingress of moisture. Packing materials must not give off corrosive vapours which may harm the finish of the product.

To ensure that the user fully understands dial markings and instruction plates, internationally understood symbols should be used wherever possible. Finally, the importance of adequate after-sales service cannot be overstressed. These things, together with a supply of spare parts, are essential if customer satisfaction is to be maintained. Some firms are aware of the pitfalls in the export market, but many are not, and the Common Market may increase their difficulties, even to the extent of bankruptcy.

Designers have an important task—a prime task—but they need to be supported by the men on the shop floor. There must be an end to petty demarcation squabbles between crafts, the tying of all loose ends between design and production, and a better understanding between personnel at all levels. Let the unions concentrate on these things and leave politics to the professional politicians.

The world does not owe us a living—we must fight to maintain our standards.

The Editor

VIBRATION OF BEAMS IN BENDING

The Rayleigh equations for calculating the fundamental frequency of bending vibration of a heavy beam without concentrated loads are described. Frequency equations are also given for the case of a heavy beam carrying a number of concentrated loads

by **W. CARNEGIE, Ph.D., B.Sc., M.I.Mech.E.***

THE fundamental or gravest frequency of bending vibration of beams can be calculated by the energy method of Rayleigh[1]. Two approaches to the problem are possible. In the first, a series of curves are assumed for the deflected form of the blade, and a corresponding number of frequency values are thereby determined. It is well known that the exact deflected form will give a minimum value of fundamental frequency; clearly therefore, of the chosen approximate curves, the one giving the lowest value of frequency is the nearest to being correct. In the second approach the static deflection curve is made use of, and in most cases the resulting value of frequency is a close approximation to the correct minimum value. The purposes of this article are (a) to show the relationship between the two approaches, and (b) to give some general observations on the Rayleigh method when applied to calculating the frequencies of bending vibration of beams.

Rayleigh's Method

The law of conservation of energy states that

$$T+V=\text{Constant} \quad \ldots\ldots (1)$$

where T is the kinetic energy and V the potential energy of a conservative system. In a vibrating system, when the potential energy is a maximum the kinetic energy is zero and vice-versa; thus

$$\hat{T}=\text{Constant or } \hat{V}=\text{Constant} \quad \ldots\ldots (2)$$

$$\text{Hence } \hat{T}=\hat{V} \quad \ldots\ldots (3)$$

which is a statement of Rayleigh's principle for conservative vibrating systems.

Application to Beams

Fig. 1 shows a heavy beam of length L executing small vibrations, the amplitude at distance z from one end being represented by $y(z)$. Denoting $w(z)$, $y(z)$ and $I_{zz}(z)$ by w, y and I_{zz} respectively the strain energy V is given by Den Hartog[2]

$$\hat{V}=E/2\int_0^L I_{zz}\, y''^2\, dz \quad \ldots\ldots (4)$$

and the kinetic energy $\hat{T}$ is also given by Den Hartog[2]

$$\hat{T}=p^2/2g\int_0^L w\, y^2\, dz \quad \ldots\ldots (5)$$

Hence, the application of Rayleigh's principle, equation (3), gives

$$p^2=\frac{Eg\displaystyle\int_0^L I_{zz}\, y''^2\, dz}{\displaystyle\int_0^L w\, y^2\, dz} \quad \ldots\ldots (6)$$

where I_{zz} and w are known functions of z. Thus, by choice of a deflected form for y, the frequency p can be determined. A number of curves should be chosen to fit the boundary conditions of the problem; of the resulting frequency values, the lowest will be the nearest to the exact minimum value of p. The difficulty arises in choosing

*Head of the department of civil and mechanical engineering, Battersea College of Advanced Technology, London.

the deflected form of y. In a recent paper by the author[3], dealing with pre-twisted beams of parallel cross-section, it is shown that, by use of the static deflection curve, calculated values of gravest frequency are obtained which show close agreement with corresponding values determined by experiment. It is not unreasonable therefore to assume, when a beam is straight but tapered, that the static deflection curve will be a suitable choice for the deflected form. The static deflection curve may be used directly in equation (6), or alternatively a somewhat more convenient form of equation can be made use of, namely

$$p^2 = \frac{g\int_0^L w\, y\, dz}{\int_0^L w\, y^2\, dz} \quad \ldots\ldots (7)$$

Hence by use of the static deflection curve, which can be readily determined, the frequency p can be calculated, since the form of $w(z)$, equal to $\rho A(z)$, is known.

Relationship between Equations

The numerators of equations (6) and (7) can be shown to be equivalent. Rewriting the integral in the numerator of equation (6) gives

$$\int_0^L [I_{zz}\, y'']\, y''\, dz \quad \ldots\ldots (8)$$

On integrating by parts, integral (8) becomes

$$\left(I_{zz}\, y''\, y'\right)_0^L - \int_0^L (I_{zz}\, y''' + I'_{zz}\, y'')y'\, dz \quad \ldots\ldots (9)$$

Integration by parts a second time gives

$$\left(I_{zz}\, y''\, y' - I_{zz}\, y'''\, y - I'_{zz}\, y''\, y\right)_o^L + \int_0^L (I_{zz}\, y'''' + 2I'_{zz}\, y''' + I''_{zz}\, y'')\, y\, dz \quad \ldots\ldots (10)$$

The first part of expression (10), the boundary term, is equal to zero for the boundary conditions of standard types of beams, i.e. simply supported, free-free, cantilever, etc. For a stepped or tapered beam when pre-twist is absent, the rate of static loading w is given by

$$w = E\, d^2/dz^2\, [I_{zz}\, y''] \quad \ldots\ldots (11)$$

which on double differentiation becomes

$$w = E(I_{zz}\, y'''' + 2I'_{zz}\, y''' + I''_{zz}\, y'') \quad \ldots\ldots (12)$$

Making use of equation (12) in the second part of expression (10) gives

$$1/E\int_0^L w\, y\, dz \quad \ldots\ldots (13)$$

Thus integrals (8) and (13) are shown to be equivalent. Substitution of integral (13) for integral (8) in the numerator of equation (6) gives equation (7), and the equivalence of equations (6) and (7) is thereby proved.

Heavy Beams with Concentrated Loads

When a heavy beam carries a number of concentrated

Symbols Used

- $A(z)$ Area of beam cross-section.
- E Modulus of elasticity.
- $F(z)$ Shearing force.
- $I_{zz}(z)$ Second moment of area of beam cross-section about xx axis.
- L Length of beam.
- $M(z)$ Bending moment.
- R Reaction.
- T Kinetic energy.
- $\hat{T}$ Maximum kinetic energy.
- V Potential energy.
- $\hat{V}$ Maximum potential energy.
- $W_1, W_2 \ldots W_n$ Concentrated loads.
- g Gravitational acceleration.
- n Integer.
- p Natural circular frequency.
- $w(z)$ Weight per unit length of beam.
- $y(z)$ Amplitude of vibration in y direction at distance z along beam.
- $y_1, y_2 \ldots y_n$ Amplitudes of concentrated loads $W_1, W_2 \ldots W_n$.
- z Co-ordinate distance along beam.
- $z_1, z_2 \ldots z_n$ Co-ordinate distances along beam to concentrated loads $W_1, W_2 \ldots W_n$.
- xx, yy, zz. Co-ordinate axes.
- $I'_{zz}, I''_{zz}, y', y'', y''', y''''$, Differentiation with respect to z is denoted by dashes thus:
- ρ Density.

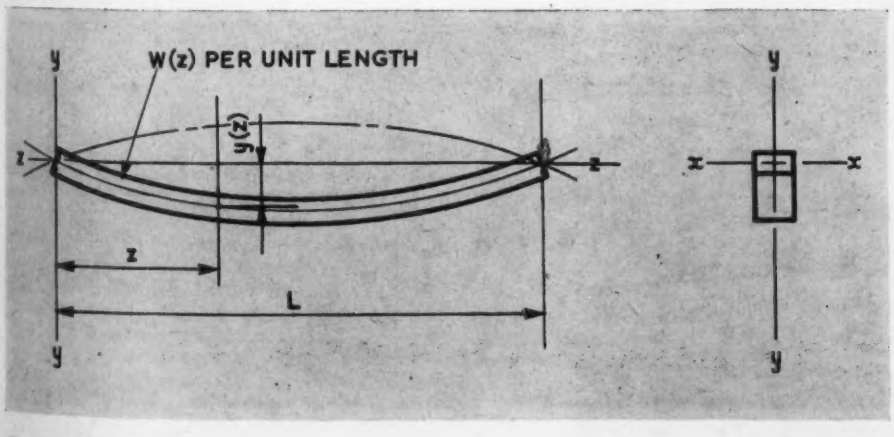


Fig. 1. Heavy beam without concentrated loads.

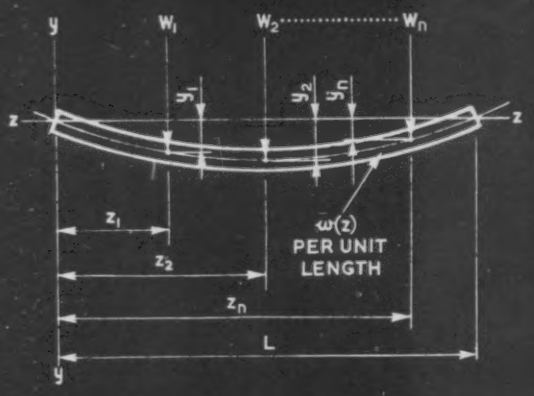
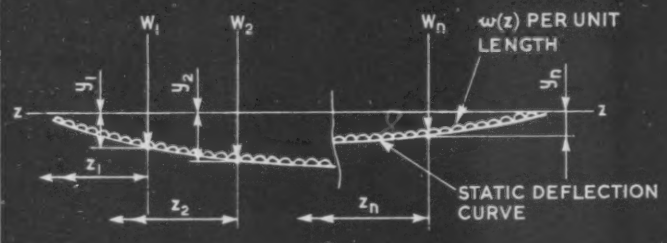
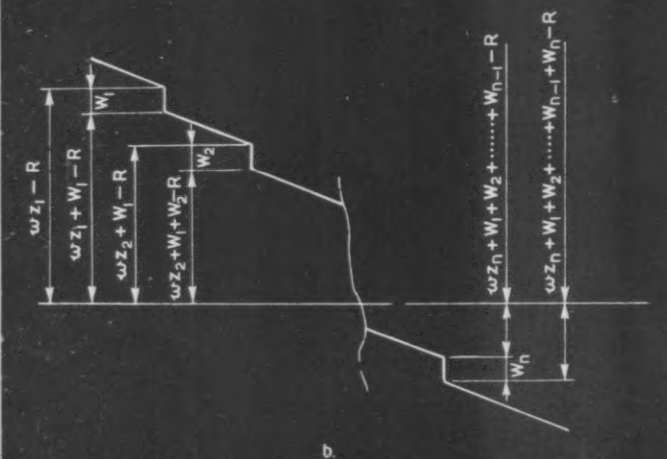


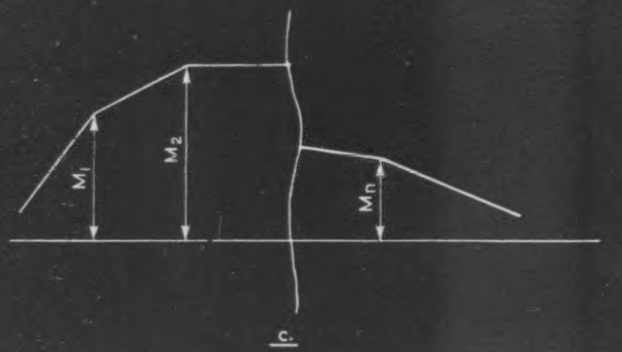
Fig. 2. Heavy beam with concentrated loads.



a.



b.



c.

Figs. 3(a) to (c). Shearing force and bending moment diagrams for a loaded heavy beam: (a) loading diagram; (b) shearing force diagram; (c) bending moment diagram.

loads $W_1, W_2 \ldots\ldots W_n$ (see Fig. 2), equation (6) becomes

$$p^2 = \frac{E\,g\int_0^L I_{zz}\,y''^2\,dz}{\int_0^L w\,y^2\,dz + \sum_1^n W_n\,y^2_n} \quad \ldots\ldots (14)$$

and the corresponding equation, analogous to equation (7) is given by

$$p^2 = \frac{g\int_0^L w\,y\,dz + \sum_1^n W_n\,y_n}{\int_0^L w\,y^2\,dz + \sum_1^n W_n\,y^2_n} \quad \ldots\ldots (15)$$

It can be readily shown that the additional term $\sum_1^n W_n y_n$ in the numerator of equation (15), arises from the boundary term of expression (10). Since $M(z) = EI_{zz}\,y''$ and $F(z) = d/dz\ (EI_{zz}\,y'')$ the boundary term can be written in the form

$$1/E \sum_1^n \Big(M\,y' - F\,y \Big)_a^b \quad \ldots\ldots (16)$$

where $M(z)$ and $F(z)$ are denoted by M and F.

Integration must be performed over each section, a to b, of the beam between adjacent pairs of concentrated loads, W_a and W_b. Thus referring to Fig. 3, which shows the static deflection curve of a loaded heavy beam or shaft, together with its corresponding shearing force and bending moment diagrams, expression (10) becomes

$$1/E\Big(M\,y' - F\,y \Big)_0^1 + 1/E\Big(M\,y' - F\,y \Big)_1^2 + \ldots\ldots$$
$$\ldots\ldots + 1/E\Big(M\,y' - F\,y \Big)_n^L$$
$$+ 1/E\int_0^1 w\,y\,dz + 1/E\int_1^2 w\,y\,dz + \ldots\ldots$$
$$\ldots\ldots + 1/E\int_n^L w\,y\,dz \ldots\ldots (17)$$

The integrals can be lumped together and written as follows, namely

$$1/E\int_0^L w\,y\,dz \ldots\ldots (18)$$

Integral (18) may require a step by step solution depending on the shape of the beam. Returning to the boundary part of expression (17), the lower limit of the first term is clearly zero for standard types of beam. Similarly the upper limit of the final term is also zero. Hence substitution of the limiting values of M and F at stations $1, 2 \ldots\ldots n$ (see Fig. 3), in the boundary part of expression (17), gives

$$1/E\,[(M_1\,y'_1 - F_1\,y_1) - 0]$$
$$+ 1/E\,[(M_2\,y'_2 - F_2\,y_2) - (M_1\,y'_1 - F_1\,y_1)]$$
$$+ 1/E\,[(M_3\,y'_3 - F_3\,y_3) - (M_2\,y'_2 - F_2\,y_2)] + \ldots\ldots$$
$$+ 1/E\,[(M_n\,y'_n - F_n\,y_n) - (M_{n-1}\,y'_{n-1} - F_{n-1}\,y_{n-1})]$$
$$+ 1/E\,[0 - (M_n\,y'_n - F_n\,y_n)] \ldots\ldots (19)$$

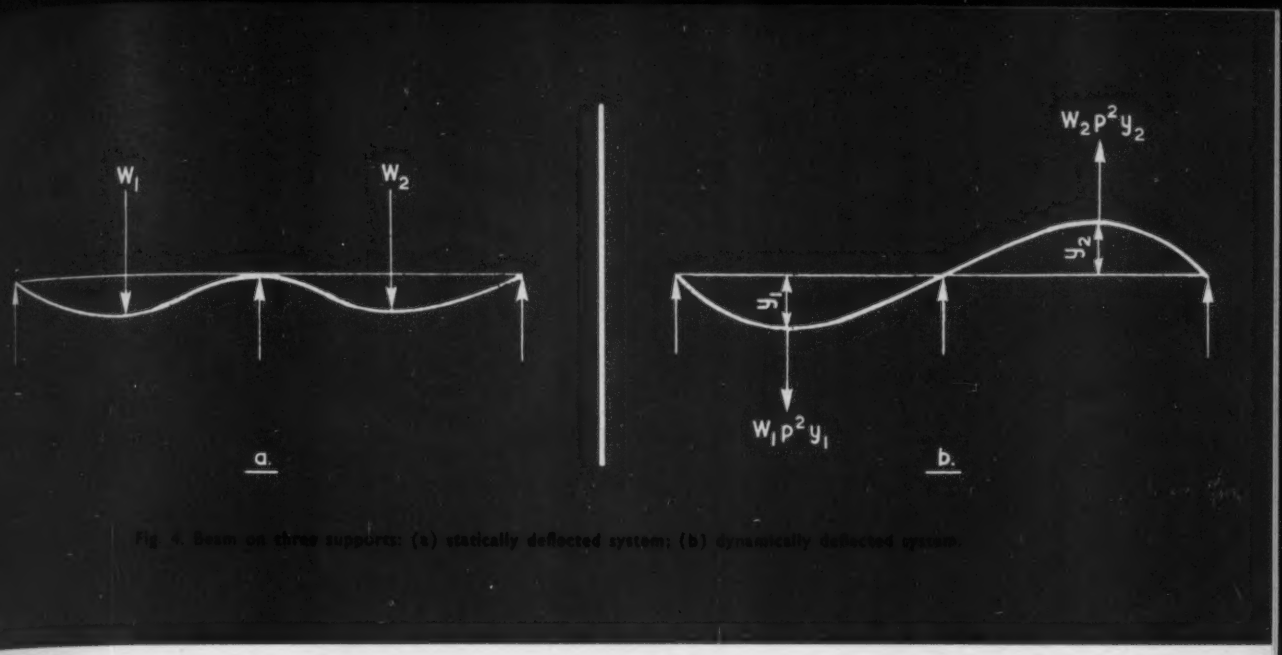


Fig. 4. Beam on three supports: (a) statically deflected system; (b) dynamically deflected system.

Clearly, since the bending moment diagram (Fig. 3b) is continuous in magnitude, the bending moment term $\sum_{1}^{n} M_n y'_n$ is zero. $M_1 y'_1$ in the first bracket cancels with $M_1 y'_1$ in the second bracket. Similarly, $M_2 y'_2$ in the second bracket will cancel with a corresponding term for load W_2, and so on over the entire loading system $W_1, W_2 \ldots W_n$. The shearing force diagram (Fig. 3c) has discontinuities of W_n at each of the stations y_n due to the concentrated static loading. The shearing force term, $\sum_{1}^{n} F_n y_n$, thus becomes

$$[(w z_1 + W_1 - R) - (w z_1 - R)] y_1$$
$$+ [(w z_2 + W_1 + W_2 - R) - (w z_2 + W_1 - R)] y_2$$
$$+ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$+ [(w z_n + W_1 + W_2 + \ldots\ldots + W_{n-1} + W_n - R) - (w z_n + W_1 + W_2 + \ldots\ldots + W_{n-1} - R)] y_n \ldots\ldots (20)$$

Providing that the static deflection curve is made use of, $\sum_{1}^{n} F_n y_n$ reduces to $\sum_{1}^{n} W_n y_n$, and thus expression (10) can be written as

$$1/E \int_0^L w y \, dz + 1/E \sum_{1}^{n} W_n y_n \ldots\ldots (21)$$

Integral (8) and expression (21) are thereby shown to be equivalent for the case of a heavy shaft carrying a number of concentrated loads. Substitution of expression (21) for integral (8) in the numerator of equation (14) gives equation (15) as required.

Equations (14) and (15) are the standard forms of equation used for determining the fundamental frequency of bending vibration of turbine rotor shafts carrying a number of rigidly attached discs. When the shaft is light in weight relative to the weight of the discs, equation (15) reduces to the standard form of:

$$p^2 = \frac{g \sum_{1}^{n} W_n y_n}{\sum_{1}^{n} W_n y^2_n} \ldots\ldots (22)$$

Conclusions

The use of equations (14) or (15) for calculating the fundamental frequency of vibration of loaded heavy beams with up to two supports is a matter of choice. Similarly when concentrated loads are absent, either of the equations (6) or (7) may be used. When equations (6) or (14) are made use of, the form of the elastic curve is unrestricted within the limits of (a) satisfying the boundary conditions of the problem, and (b) being a reasonable representation of the true form of the elastic curve. To ensure reasonable accuracy, however, several calculations are required using a series of elastic curves. By use of equations (7) or (15) reasonable accuracy can be ensured after one calculation, but some initial effort is expended in determining the static deflection curve. On balance it is likely that the second method of approach using the static deflection curve will lead more speedily to a accurate value of p. Furthermore, other forms of elastic curve can be made use of in equations (7) or (15), although clearly the accuracy of p, relative to the correct value, will be less than the corresponding value determined by the first method when equations (6) and (14) are used.

The application of Rayleigh's method to the calculation of frequencies of beams with more than two supports requires special care. This is made clear in Fig. 4, which shows the static and dynamic deflection curves to be greatly different in form. Thus the use of equations (7) and 15 for determining the fundamental frequency p, using the static deflection curve, is precluded. Equations (6) and (14) should be made use of for the calculation of fundamental frequencies of beams with more than two supports.

REFERENCES

1. Lord Rayleigh, *Theory of Sound*, Macmillan & Co. Ltd., London, 1896.
2. J. P. Den Hartog, *Mechanical Vibrations* (third edition), McGraw-Hill Book Company Inc., New York and London, 1947.
3. W. Carnegie, "Vibrations of Pre-twisted Cantilever Blading", *Proc. Instn. Mech. Engrs.*, 173, No. 12, p. 343, London, 1959.

LETTERS TO THE EDITOR

Problem in Design No. 17

Sir,

We are honoured that our solution to your March 1961 problem should have received such high praise from your excellent magazine.

However, in all honesty we are obliged to correct your statement that "there is no axial component in either direction". Arguments on this point nearly resulted in the break-up of the Varell Syndicate, but consideration showed that, in fact, the thrusts from camshaft and crankshaft both act in the same direction. A double helical wheel is, of course, in balance when both sides are being driven, whereas in our design one side is *driven* while the other side *drives* the camshaft.

It is interesting to note that a single helical wheel is indeed in balance but, as you state, imparts no phase change. Our sympathy is extended to the nameless one who "fell into this booby trap" —he was very nearly in good company!

G. A. Varley

The Varell Syndicate,
7 Avenue Road, Bexleyheath, Kent.

Problem in Design No. 18

Sir,

We were most interested to read in your August 1961 issue, which also carried one of our advertisements, the article headed "Problems in Design".

This dealt with various ingenious attempts to obtain a mechanical sequence timing device. All those contributors interested in this problem would, we are sure, be interested in our Masterotor Control which gives this exact effect with extreme simplicity and flexibility, providing means to select a sequence and timing in a few seconds. This unit is standard equipment on all large body presses at the Ford Motor Co. and the Pressed Steel Co. for the control of mechanical handling equipment in conjunction with the presses.

The unit was awarded a Gold Medal in the engineering section at the International Inventors Exhibition, at Brussels in 1958, and received a special mention as being the most outstanding British invention of that year.

In view of your readers interest in this particular problem we hope you will find space to draw their attention to it.

I. M. Furnivall

I.G.E. (Control Equipment) Ltd.,
Interlock Works,
Court Road,
Birmingham 12

Data Sheet No. 64

Sir,

Your Data Sheet No. 64 ("Buckling Stresses of Curved Panels in Shear", August 1961) baffles me, and my design staff are equally at sea, so no doubt many of your readers would be glad of some clarification.

How are the panels supported? How is the load applied?

S. Zillwood Milledge

2 Elthorne Road,
Crosfield, London, N.19

We apologise to Mr. Milledge and other readers baffled by this Data Sheet.

The shears quoted on Data Sheets Nos. 60 (*"Buckling Stresses of Flat Plates in Shear", May* 1961) *and* 64 *are obviously uniform and therefore must be uniformly applied along the sides of the panel. If the shear were applied in any other way, e.g. point loads at the corners, the problem would be one of shear diffusion, and the form of the data sheet would be entirely different.*

In Data Sheet No. 64 *the edges are simply supported. In a flat panel the buckling stress may be appreciably affected by the edge conditions, but in the case of a curved panel the resistance to buckling stems from the fact that a line along the outward crest of a buckle has increased in length whereas a line along the inward crest of a buckle has decreased in length. Since buckling is due to the plate taking the shear as diagonal tension with a corresponding induced compression at right angles to the tension field, it follows that in the case of a curved plate the elongation due to the tension field must be greater than the decrease in length along the inward crest. Therefore in the direction of the tension field all sections of the plate must be at zero or positive tension stress, thus inducing the compression stresses at right angles which produce the buckling. The resistance of a curved panel to buckling comes predominantly from the curvature and not from the edge conditions.*

The curvature parameter is the $b/\sqrt{Rt}$ *or* $a/\sqrt{Rt}$ *term. Only when* R *is large compared with the other dimensions of the panel, and hence the parameter very small, will the reduction in length along the inward crest be small, reducing the resistance to buckling due to the curvature and allowing the method of edge fixation to affect the buckling stress. In this region the curves are insensitive and approximate to curves* (3) *and* (4) *of Data Sheet No.* 60. *The effect of edge fixation may, therefore, in this region be obtained by comparison with graphs* (1) *and* (2) *of that sheet. This should not be used for values of* $b/\sqrt{Rt}$ *greater than about* 7.

When R *is relatively small compared with* a, b *and* t, *the effect of the edge conditions is negligible* ($b/\sqrt{Rt}$ *is large*).

It would have been possible to draw four families of curves each family being similar to one of the curves of Data Sheet 60, *but the result would have been confusing.*

EDITOR

Bus Design

Sir,

You report (on page 497 of the August 1961 issue) a new design for a city bus by Leyland's, and you describe some commendable features: fast loading and unloading, reduction of capital and operating costs, and the rear position of the engine.

Similar but more restricted engineering thinking has led to the Routemaster. Although the Leyland design is a better one, both suffer from what I can only describe as blindness in one direction, i.e. as the capacity of the bus increases, the service becomes worse. This is not because the big bus is slower, but because it provides an infrequent service. Is there not a case for smaller buses manned by one man, with a well-designed ticket and change machine? And if the number of buses were to be doubled, say, the provision of a proportion of standing-only buses for rush hours could be undertaken—but only if the service were frequent enough.

It has often seemed to me that engineers designing buses remember only that they are engineers, and not that they are, or have been, bus travellers.

E. Palfrey

Townsend Farms,
Townsend Lane,
Harpenden, Herts.

Automation Progress

Sir,

While the emphasis today is on automation, it is as well to pause to reflect upon the comparative approach to the subject. British industry is largely influenced by customers' demand; Soviet by producer demand; American by selling demand.

The overall effect of these differences could be that in our country we are likely to have a lower volume production than the other two, and that in consequence we must avoid going ahead with development in automation too rapidly, to avoid running into the backwater of stagnation and economic bankruptcy.

In this country we have had—although we are fast losing—a reputation for high-quality and long-endurance cars, in the days when these were the hall-mark of British manufacture. Latterly, however, we have fallen behind because of insistence on following American standards and sales policy, hinged to advanced automation methods in the battle for production supremacy.

That we have succeeded all too well over the past two years is shown by a volume beyond the shrewdest expectation of our largest car factories. Alas, that growth is not being maintained! So now we reach the final analysis of realising the necessity for being extremely cautious in the way we adopt automation in our own country, and for avoiding overdoing it to the stage of no return, by returning to smaller-scale methods.

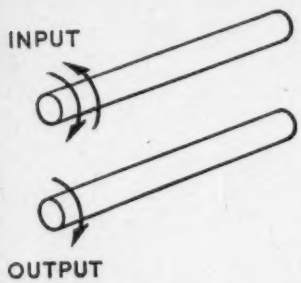
We shall do well to reduce overheads and unit cost if we are to win through, and to pierce the armour of twentieth century competition and withstand the overall impact of the Common Market.

Francis B. Willmott

Forward Works,
River Street,
Birmingham 5

PROBLEMS IN DESIGN

Problem No. 20 (June): Devise a mechanism which will enable an input shaft, the direction of rotation of which may



be subject to reversal, to transmit unidirectional rotation to a shaft parallel with it regardless of its own direction of rotation.

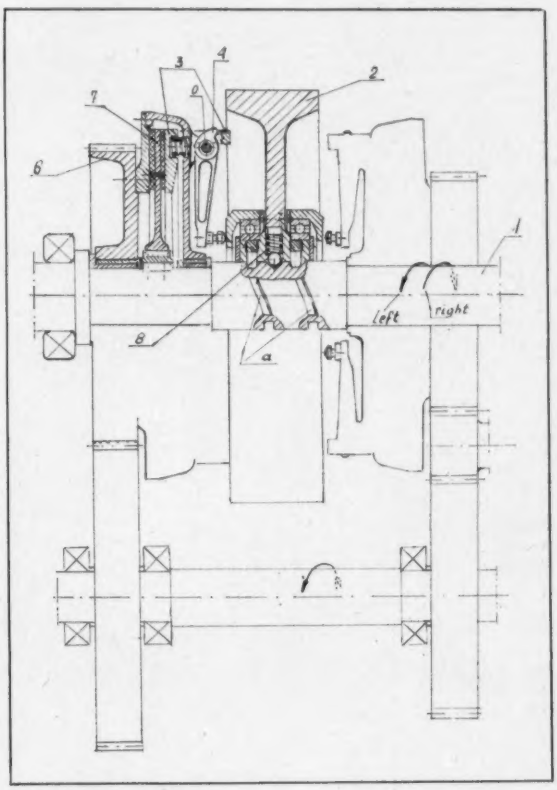
In selecting problems for this feature we endeavour, as a rule, to find ones which constantly turn up, in one form or another, in design work. We prefer to set problems which give a fair amount of latitude in approach, the resulting entries being varied and interesting. In setting the above problem, however, we were not ourselves aware of many different solutions. It came as no surprise, therefore, to find that one large group of entries were on almost identical lines.

This kind of entry, three examples of which are shown, employs two freewheels or sprag clutches. The examples shown, which came from **J. F. Jackson, T. A. Henshaw** and **D. Lightfoot,** are similar in layout, the only difference between them being in the positioning of the freewheels. In Mr. Jackson's entry, when the input shaft rotates clockwise, the output shaft is driven counter-clockwise by the spur gears on the input and output shafts. When the input shaft rotates counter-clockwise, the output shaft is driven clockwise via the idler gear. The other two examples of this sort of entry merely position the freewheels differently, and achieve the same result.

A somewhat more compact version of the same idea, suggested by Mr. Jackson in his letter, eliminates the need for an idler gear and uses chain sprockets in addition to gears. Entries embodying this principle were received from **L. S. Horvath, P. Major** and **M. J. Mitchell.** For one direction of drive the spur gears transmit torque, for opposite rotation the chain drive operates.

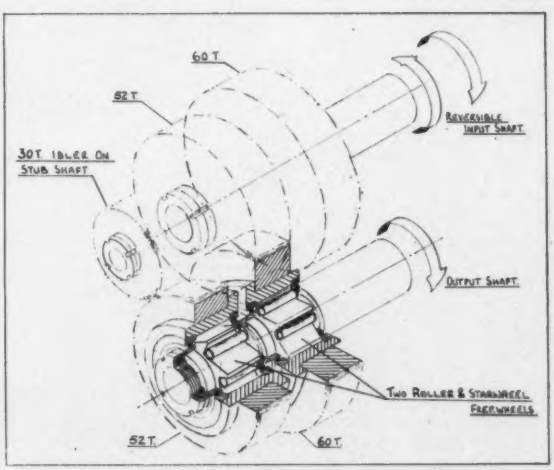
The above-mentioned types, embodying proprietary types of freewheel or sprag clutch, would be particularly suitable for situations where it was essential to eliminate lost motion on reversal, as would be necessary where the input shaft underwent frequent reversals or perhaps only reciprocated a few degrees. The proprietary units mentioned are almost backlash free and full advantage would be taken of this feature.

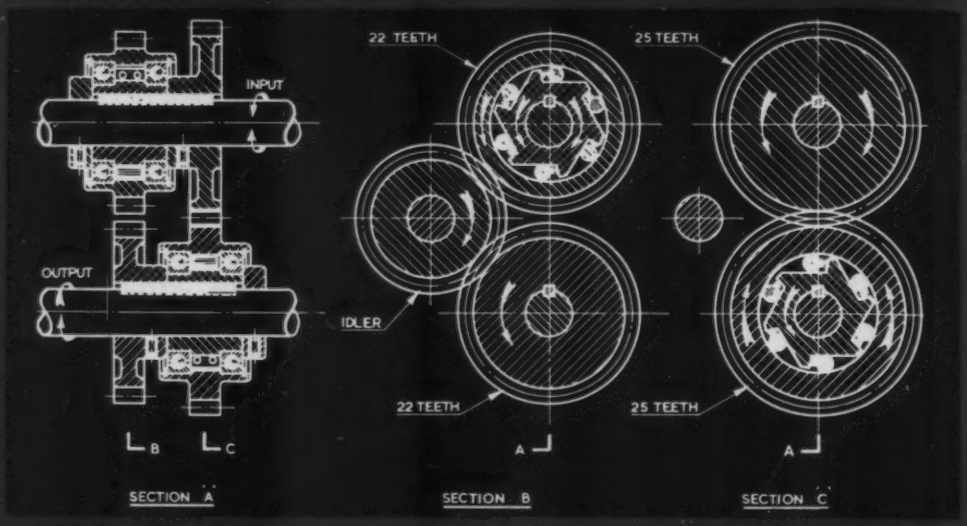
For situations where lost motion did not matter appreciably, certain other types of entry received might be more



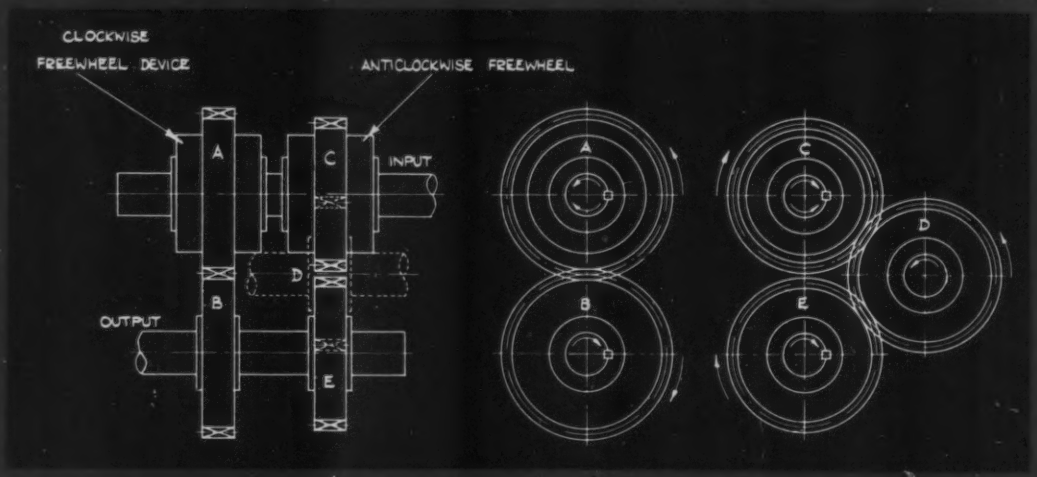
J. ANDRZEJEWSKI

D. LIGHTFOOT

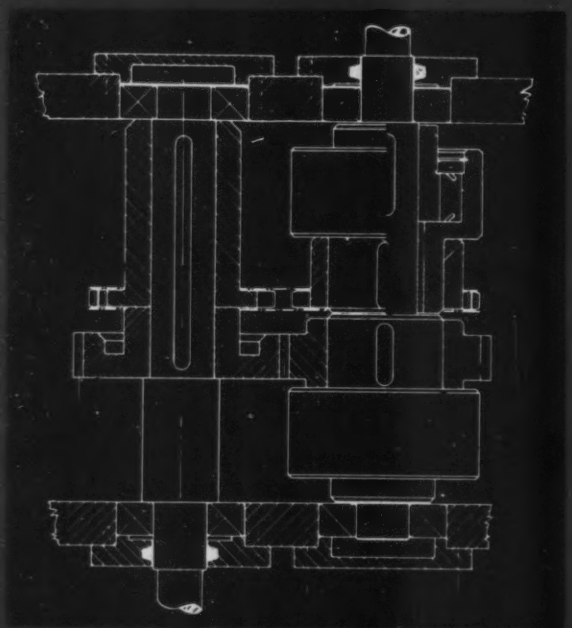




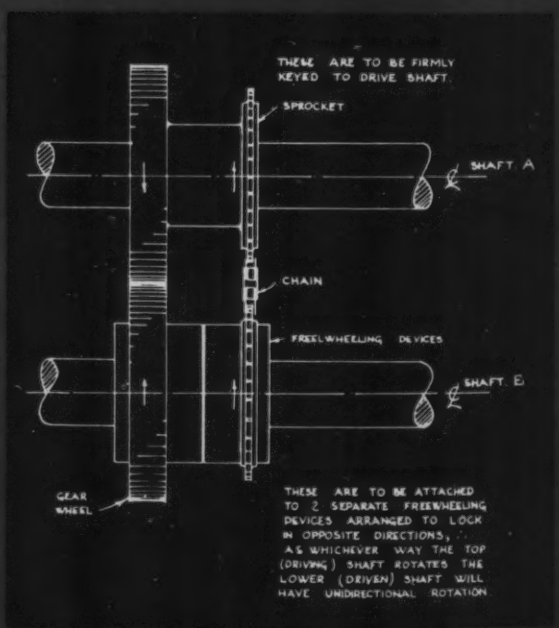
J. F. JACKSON



T. A. HENSHAW

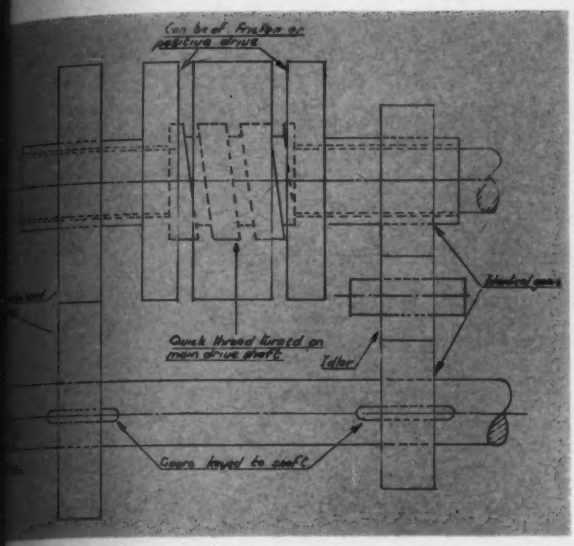


L. S. HORVATH

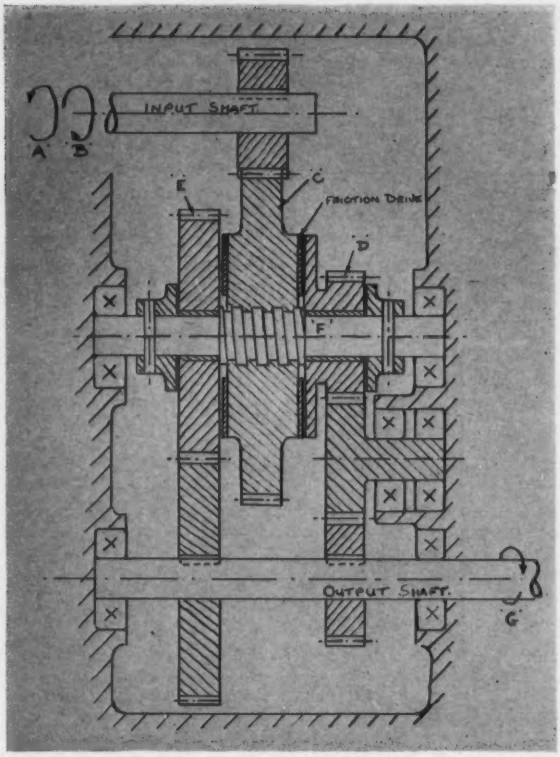

THESE ARE TO BE FIRMLY KEYED TO DRIVE SHAFT.
SPROCKET
SHAFT A
CHAIN
FREEWHEELING DEVICES
SHAFT B
GEAR WHEEL
THESE ARE TO BE ATTACHED TO 2 SEPARATE FREEWHEELING DEVICES ARRANGED TO LOCK IN OPPOSITE DIRECTIONS, AS WHICHEVER WAY THE TOP (DRIVING) SHAFT ROTATES THE LOWER (DRIVEN) SHAFT WILL HAVE UNIDIRECTIONAL ROTATION

M. J. MITCHELL

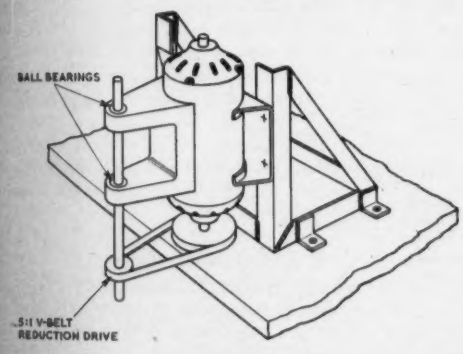
F. G. KEELING



C. H. WOODWARD



PROBLEM IN DESIGN No. 24
Here is this month's problem



The above sketch represents the prototype of a special-purpose machine which uses a standard ¼-h.p. induction motor. The machine is mounted on a table or bench so that the driven spindle, to both ends of which special small attachments are fitted, projects over the edge as in the sketch. The V-belt drive is provided with a crude sheet-metal guard (not shown).

The problem is one of "Industrial Design". A production design discarding the crude angle-iron construction, is required, having eye appeal while maintaining the same kind of drive and the same spatial relationships between the motor, the driven shaft and its bearings. The new design must incorporate a belt guard.

The motor chosen need not be of the foot-mounting type illustrated.

Best solutions to "Problems in Design" are published and paid for. Send your solution for this month, with a drawing or diagram (in Indian ink and not more than 12 × 12 in., please!) to the Editor, "Problems in Design No. 24 (October)". Closing date November 20th.

suitable. **J. Andrzejewski,** of Warsaw, employs an ingenious but rather complicated clutch principle. The input shaft *1* carries, at its centre, a flywheel *2* which is free to rotate and also move axially by reason of helical grooves on the shaft. (This would seem to present a serious assembly problem as drawn!) When the input shaft rotates in the left-hand direction, shown by the arrow, the flywheel will be on the left side and will move to the right when the input shaft rotation is reversed. Movement of the flywheel operates clutch levers to disengage the left- or right-hand clutch. Drive on the left side is by direct spur gear to the output shaft, and on the right side is via an idler gear. A light detent to secure the flywheel is provided by the spring and ball arrangement *8*. When the drive shaft changes its direction of rotation, the inertia of the flywheel will overcome the detent spring resistance and then be able to slide to the other extreme position.

Although this entry is ingenious and could transmit large torques, we feel that, with a minor addition, **F. G. Keeling's** entry would be both simpler and better. A thread of large helix angle is cut at the enlarged centre portion of the input shaft. This carries a large nut of flywheel proportions, each side of which carries friction surfaces. The bushed spur wheels also mounted on the input shaft transmit torque, via their faces, to the output shaft either directly or via an idler gear. In this case we feel that the addition of a slight frictional restraint of the clutch nut unit, possibly a spring-operated pad, would be essential to ensure that the unit did, in fact, move axially. Inertia alone might not be sufficient to bring about this movement. The advantage of this system, however, is that the force engaging the clutch face is proportional to the torque transmitted.

C. H. Woodward's entry, which is on the same lines, we consider to be superior although it involves more gears. His input shaft carries a spur gear which positively drives the friction drum, thereby eliminating the need for any frictional restraint. This arrangement would be more positive in action.

HEAT-TREATABLE TITANIUM SHEET ALLOYS

The Author compares the high-strength beta-titanium alloys B120 VCA (Crucible Steel Co. of America) and Ex011 (Imperial Chemical Industries Ltd.), and suggests possible fields of application for them

by D. GOOLD*

IN the past few years considerable effort has been expended in both Britain and the U.S.A. on developing heat-treatable titanium sheet alloys. The objective has been to obtain an alloy which in the soft condition would be readily formable and after heat-treatment have high strength with adequate ductility. Investigation has concentrated on the meta-stable beta phase alloys since in the all-beta condition they are generally soft and ductile, and after heating within a particular temperature range the beta phase decomposes to an alpha plus beta structure which leads to considerable strengthening. In the U.S.A. most interest has been focused on B120 VCA, an alloy containing 13% vanadium, 11% chromium and 3% aluminium, whereas in this country I.C.I. have developed Titanium Ex011, which contains 15% molybdenum. In this article the properties of these two alloys are compared, using results determined in I.C.I.'s laboratories and other published results. The B120 VCA sheet used was 16 gauge material of recent American manufacture and the Ex011 sheet was from current manufacture. Most of the results are for sheet, but a few rod results are also included.

Both alloys are denser than pure titanium, the values being 4·82 gm./cc. for B120 VCA, and 4·96 gm./cc. for Ex011—as compared with 4·51 gm./cc. for pure titanium.

Soft Solution-treated Properties

Both alloys are usually prepared in the soft meta-stable beta condition, typical sheet tensile properties in this condition being listed in Table 1. Neither alloy exhibits appreciable directionality. Minimum bend radius for B120 VCA has been quoted as being between 1t and 3t. In this investigation sheet was bent round a 1t former without fracturing, but a severe "orange peel" effect was present on the outside of the bend, and to eliminate this the radius of the former had to be increased to 3t. The orange peel effect was caused by the large grain size of the sheet, which is indicative of production by a hot rolling process. Ex011 can be satisfactorily bent round a 0·5t former.

Formability

Both alloys can be cupped satisfactorily, but the maximum depth of cup is probably greater for Ex011. From the high proof stress/u.t.s. ratio and low uniform elongation it is not expected that B120 VCA will be very amenable to stretch forming. On the other hand, Ex011 can be stretch formed, permanent extensions of over 10% having been obtained, although further development is necessary to establish the optimum conditions for stretch forming.

Age Hardening and Properties

Both alloys can be aged within a range of temperatures to obtain different strength levels. The recommended aging temperature range for B120 VCA is 450 to 480 deg. C. and for Ex011 500 to 550 deg. C.; aging times for B120 VCA are up to 100 hr., and for Ex011 from 4 to 16 hr. Typical aged tensile properties at a similar elongation level are shown in Table 2. If B120 VCA is cold worked prior to aging, rate of aging is increased, and aging times to achieve a given strength are drastically reduced. As a consequence of this, if a fabricated structure having different degrees of cold work in various parts is aged, strength will vary throughout the aged structure. Cold work prior to aging has little effect on the aged properties of Ex011. This difference is readily explained since B120 VCA is usually used in the under-aged condition, where strength is still increasing with aging time, whereas Ex011 is used in the over-aged condition, where strength is substantially independent of aging time. If B120 VCA is heavily cold worked and then aged, strengths of over 110 t.s.i. can readily be obtained, whereas the maximum strength that can be developed in Ex011 is about 95 t.s.i.

*The author is a member of the research department, Metals Division, Imperial Chemical Industries Ltd.

Table 1. Mechanical properties of solution-treated sheet

Property	B120 VCA (15 min. at 800°C., air cooled)	Ex011 (15 min. at 800°C., water quenched)
0·1% p.s. (t.s.i.)	59·6	34·1
U.t.s. (t.s.i.)	62·4	48·2
%Elongation on 2 in.	13	24
%Uniform elongation	3	18
Min. bend radius ..	1—3t	0·5t

Table 2. Mechanical properties of sheet in the aged condition

Property	B120 VCA (aged 100 hr. at 450°C.)	Ex011 (aged 16 hr. at 500°C.)
0·1% p.s. (t.s.i.)	84·2	75·3
U.t.s. (t.s.i.)	95·0	84·9
%Elongation on 2 in.	5	5

Table 3. Mechanical properties of welded alloys

Property	B120 VCA		Ex011	
	As welded	Welded and aged 50 hr. at 450°C.	As welded	Welded and aged 16 hr. at 525°C.
0·1% p.s. (t.s.i.)	60·8	77·2	35·3	66·5
U.t.s. (t.s.i.)	64·9	88·2	48·6	73·1
%Elongation on 2 in.	10	3·5	23	4
Min. bend radius	4·8t	—	0·5t	—

Table 4. Mechanical properties of aged rod

Property	B120VCA (aged 64 hr. at 450°C.)	Ex011	
		Beta, solution treated and aged 16 hr. at 475°C.	Alpha plus beta, solution treated and aged 16 hr. at 475°C.
0·1% p.s. (t.s.i.)	95·6	87·0	83·1
U.t.s. (t.s.i.)	102	93·1	89·0
% Elongation on $4\sqrt{A}$	3	6	13
%Reduction in area	9	11	60

Weldability

Both alloys are readily weldable provided the usual precautions for welding reactive metals are observed. The samples of B120 VCA welded for this investigation had a tendency to hot crack, a phenomenon which has not been previously reported for this alloy. In the as-welded condition, the properties of both B120 VCA and Ex011 are similar to those of the parent sheet. After welded B120 VCA has been aged its strength approaches that of the parent sheet, although elongation is less, whereas the aged strength of welded Ex011 is less than that of parent sheet. Typical results are presented in Table 3. It should be emphasised that, with beta titanium alloys, oxygen preferentially diffuses down the grain boundaries even at temperatures in the region of 500 deg. C.—this effect is very pronounced in welded structures where there is a large grain size. It is necessary to remove all the oxygen-enriched layer before testing, or else protect the surface during aging, otherwise ductility is drastically reduced.

Creep

In the aged condition both alloys have good creep strength up to a temperature of 300 deg. C., a stress in the range of 40 to 45 t.s.i. being necessary to produce 0·1% plastic strain in 300 hr. At 400 deg. C. the stress necessary to produce a similar strain decreases to between 10 and 15 t.s.i. No evidence of post creep instability has been found with Ex011. The post creep instability of B120 VCA has often been mentioned as occurring at temperatures above 200 deg. C., but little systematic data has been published. One summary of available data[1] indicates that instability increases rapidly with strain, and is very marked above 300 deg. C.

Notch Sensitivity

Samples of B120 VCA sheet aged to strengths of 90 and 98 t.s.i. are notch sensitive to a notch of stress concentration factor $K_t=4$, and the ratios of notched to unnotched strengths are 0·80 and 0·76 respectively. Samples of Ex011 aged to strengths of 70 and 90 t.s.i. respectively are not sensitive to notches of a similar severity, and the ratio of notched to unnotched strengths is 1·15 and 1·07 respectively. In the solution-treated condition neither alloy is sensitive to similar notches.

Rod Properties

To obtain optimum mechanical properties in Ex011 rod, it is recommended that the rod be solution treated in the alpha plus beta region prior to aging, instead of beta quenched as is recommended for sheet. Typical aged results for B120 VCA and Ex011 rod after both solution treatments are shown in Table 4—these demonstrate the advantage of alpha plus beta solution treatment for Ex011 rod. It is not known if similar advantages can be obtained in B120 VCA rod.

Availability of Various Forms

B120 VCA, being a relatively stiff alloy at room temperature, is hot rolled close to final size. Consequently the minimum gauge available for wide sheet is relatively thick. On the other hand Ex011 is more easily cold rolled, and thus can be rolled to much thinner gauges. Both alloys are amenable to production as extrusions, rod and wire.

Conclusions

Of the two alloys, B120 VCA is the logical choice for an application where achievement of the highest possible strength/weight ratio is paramount, and where times at high temperature are of short duration. However, the minimum gauge of wide sheet is relatively thick, and the alloy is not very amenable to severe cold forming, e.g. stretch forming. It is, therefore, not surprising that B120 VCA receives its largest application in the American missile industry. By comparison, I.C.I. titanium alloy Ex011 in the solution-treated condition is amenable to severe cold-forming operations, and may be cold rolled to thin gauges. It can be aged to give high strengths with reasonable ductility, and may be used under loads at elevated temperature without risk of any loss in ductility.

REFERENCES

1. "The All-Beta Titanium Alloy (Ti, 13% V, 11% Cr, 3% Al)", D.M.I.C. Report 110, Battelle Memorial Institute, April 17, 1959.

PART III

SURVEY OF PIPE COUPLINGS

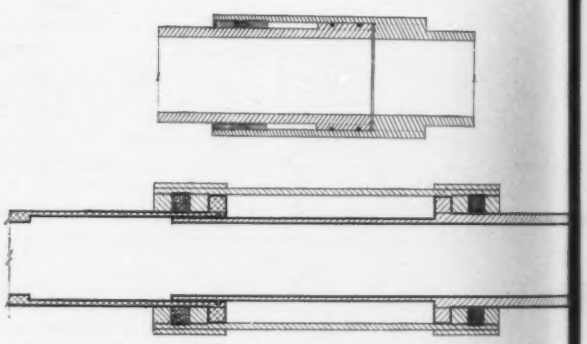
This concluding part of the author's comprehensive survey lists first, the principal suppliers of couplings for plastics and glass pipes, and finally those firms marketing couplings for flexible, swivel and rotating joints

by A. H. ROACH

COUPLINGS FOR PLASTICS PIPES

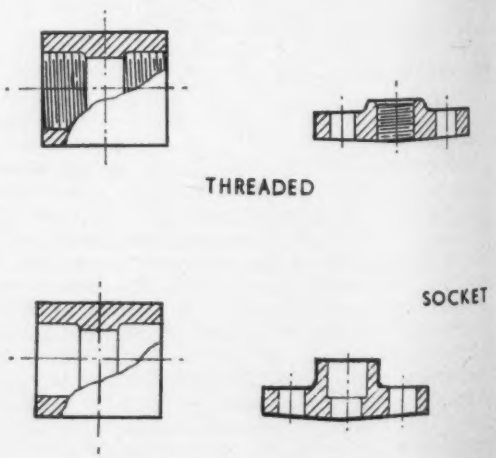
Barflo Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Chemicals Water Fuel oils	*Styrene - butadiene*, p.v.c. and high impact p.v.c. Single expansion unit Double expansion unit Flanges		Nominal size: $\frac{3}{8}$ to 6 in. $\frac{3}{4}$ to 6 in. $\frac{1}{2}$ to 6 in.



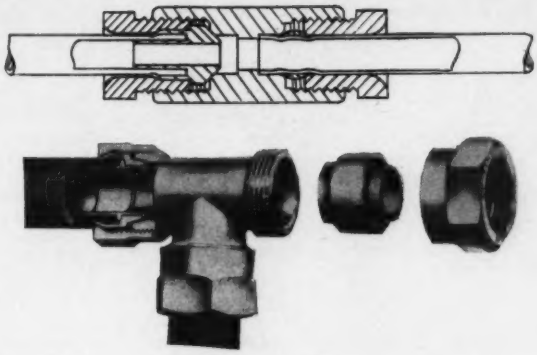
BTR Industries Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Silverflow	Chemicals Fuel oils Liquids	Rigid p.v.c. Screwed sockets 330 to 160 Sockets for welding* 575 to 195 Flanges for welding* (*Chemical or heat)	24 24	Nominal size: $\frac{1}{2}$ to 4 in. $\frac{1}{2}$ to 6 in. $\frac{1}{2}$ to 8 in.



Compression Joints Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Nitex	Hydraulics Air Lubricants Fuel	*Brass* compression couplings for *nylon* pipes.		$\frac{1}{8}$ to $\frac{1}{4}$ in. o.d.
Plastex	Water	*Brass* or *gunmetal* 340	R.T.	Nominal bore $\frac{1}{2}$ to $1\frac{1}{2}$ in.
Plastex Senior	Water	*Gunmetal* only 200	R.T.	2 in.



Conex-Terna Ltd.

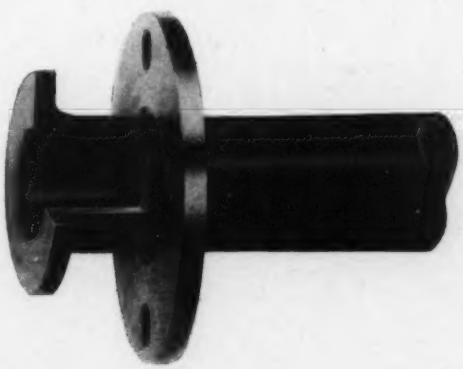
Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Conex	Water	*Brass* *Gunmetal*		Nominal size: $\frac{1}{2}$ to 2 in. $\frac{1}{2}$ to 1 in.

Durapipe and Fittings Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Durapipe K *a.b.s. copolymer*	Resistant to most chemicals	Fittings for solvent welding. Threads available on larger sizes		
		420 to 95	R.T.	Nominal size: $\frac{3}{8}$ to 6 in.
		210 to 47	60	
		(Temp. range 4 to 77°C.)		
Durapipe V Unplasticised modified *p.v.c.*	Resistant to most chemicals (Higher resistance than Durapipe K)	Fittings for solvent welding. Threads available on larger sizes		
		420 to 95	R.T.	$\frac{1}{2}$ to 6 in.
		105 to 24	40	
		Temp. range 4 to 50°C.)		
Durapipe Z High-density rigid *polythene*	Highly resistant to all chemicals	Pipe and fittings for fusion welding, or screwing		
		300 to 40	R.T.	$\frac{3}{8}$ to 6 in.
		150 to 20	50	
		(Temp. range —30 to +50°C.)		

Foster Brothers Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Bulldog	Water Chemicals Liquids	Integral *polythene* flanges		Nominal bore:
		Heavy gauge:		
		150	R.T.	1, $1\frac{1}{4}$, $1\frac{1}{2}$ and 2 in.
		Normal gauge:		
		130	R.T.	$1\frac{1}{4}$ in.
		120	R.T.	$1\frac{1}{2}$ and 2 in.
		90	R.T.	3, 4 and 6 in.
		(Higher temp. at reduced pressures)		



J. S. & F. Folkard Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Vulcathene	Chemicals Water Liquids	*Polythene* threaded sockets, or sockets for heat welding 230 to 66	R.T.	Nominal bore: $\frac{1}{2}$ to 3 in.
	Waste drainage	As above 65 to 25	R.T.	$1\frac{1}{4}$ to 6 in.
		Polythene flanges for heat welding 65 to 25	R.T.	$\frac{1}{2}$ to 6 in.
		Horizontal or vertical expansion joints, not suitable for pressures	R.T.	$1\frac{1}{2}$, 2, 3 and 4 in. (horizontal) 2, 3 and 4 in. (vertical)

Industrial Marine Protective Applications Ltd.

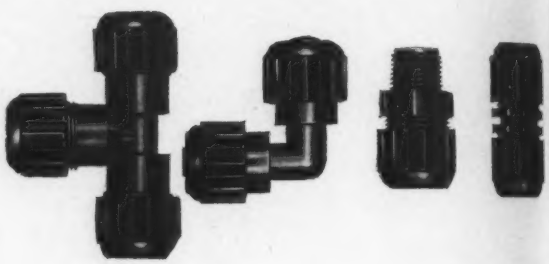
Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Chemicals Water	*Polythene* moulded or machined screwed fittings 340 to 40	R.T.	Nominal size: $\frac{1}{4}$ to 4 in.
		Shouldered flanges		$\frac{1}{2}$ to 4 in.
		Flat flanges		$\frac{1}{2}$ to 12 in.
	Chemicals Oil Paraffin Water	*P.v.c.* moulded screwed fittings 300 to 125	R.T.	$\frac{1}{4}$ to 2 in.
		Flat flanges		$\frac{1}{2}$ to 12 in.
	Chemical Oil Paraffin Water	High impact *p.v.c.* moulded or machined screwed fittings and plain sockets 240 to 100	15	$\frac{1}{4}$ to 4 in.
		Hubbed flanges 150	15	$\frac{1}{4}$ to 3 in.

Kay & Co. (Engineers) Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Kontite type A to BS 864, adapted for *polythene* tube	Gas Water Petrol Oil	*Gunmetal* and *brass* —	— —	Nominal size: $\frac{1}{4}$ to $2\frac{1}{2}$ in.

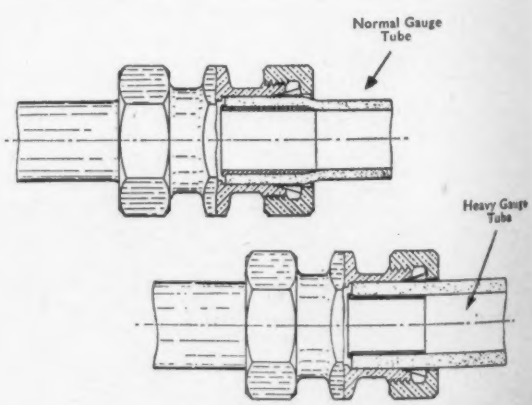
Hozelock Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Tubelock	Air Gas Water Liquids	Screwed compression fittings *Polystyrene* 250	—40 to +60	$\frac{1}{2}$ and $\frac{3}{4}$ in.
		Nylon 250	80	$\frac{1}{4}$ to $\frac{3}{4}$ in.
		Polythene 250	50	$\frac{1}{4}$ to $\frac{3}{4}$ in.
		Brass for nylon tubing		$\frac{1}{4}$ and $\frac{3}{4}$ in.



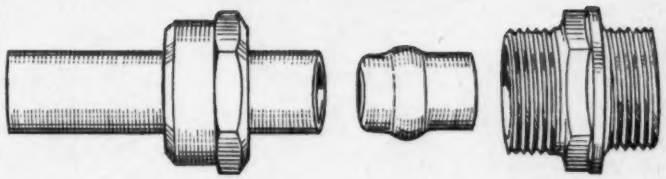
The Ketava Co. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Water systems and fume ducting	—	60	Nominal bore: $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$ and 2 in.
		Plastics — sockets, screwed and plain. Plastics — flanges, screwed and plain		



Kings Langley Engineering Co. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Kingley type B to BS 864, adapted for polythene tube	Water Gas Petrol Oil	*Brass* —	— —	Nominal size: ¼ to 2½ in.



James H. Lamont & Co. Ltd.

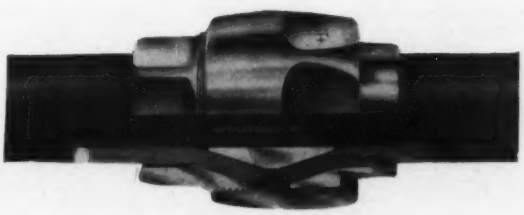
Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Securex type B to BS 864, adapted for polythene tube	Water Gas Petrol Oil	*Brass* —	— —	Nominal size: ¼ to 2½ in.

Peglers Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Prestex type A to BS 864	Water Gas Oil Petrol	*Brass* with *copper* sleeve —	— —	Nominal size: ¼ to 1¼ in.

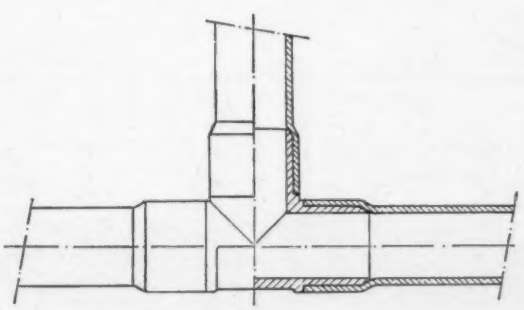
Peck & Co. N. V. (Amsterdam)

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Water	*Malleable iron* screwed fittings *Brass* screwed fittings *Polythene* screwed fittings *P.v.c.* sockets: 142 R.T.		Nominal size: 15 to 62 mm. 20 to 63 mm. 16 to 50 mm. —



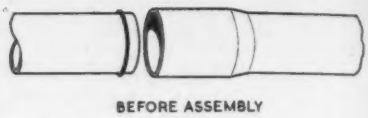
W. J. Stokvis' Royal Metalworks Ltd. (Holland)

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Wisa (for tubes to I.S.O. and inch sizes)	Liquids	*P.v.c.* fittings for solvent welding 140	R.T.	Nominal size: 8 to 63 mm.
Wisaplast (for tubing to I.S.O. only)	Liquids	*Nylon* fittings, screwed 140	R.T.	

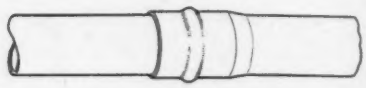


Wavin Pipes Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Shrink socket and screw type joint (integral with pipe); also flanged spigot	Water	Hard *p.v.c.* Class B 87 Class C 130 Class D 173	 R.T. R.T. R.T.	Nominal size: 2 to 6 in.
Plain sockets	Water	Hard *p.v.c.* 130	R.T.	$\frac{3}{8}$ to $1\frac{1}{2}$ in.

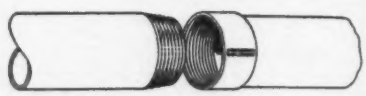


BEFORE ASSEMBLY

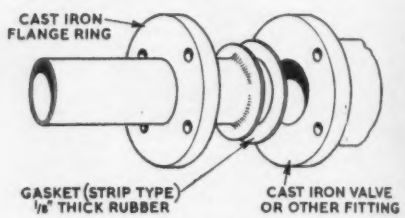


AFTER ASSEMBLY

SHRINK-TYPE JOINT



SCREW-TYPE JOINT



FLANGE RING JOINT

The Wednesbury Tube Co.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Water Chemicals	*Polythene* compression fitting 230 150 115	 R.T. R.T. R.T.	Nominal bore: $\frac{1}{2}$ in. $\frac{3}{4}$ in. 1 in.

Yorkshire Imperial Metals Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Instantor	Water Oil	*Brass* and *gunmetal* —	 —	Nominal size: $\frac{1}{4}$ to 2 in.
Plastronga	Water Chemicals	*Polythene* flanged compression fitting 230 to 130	R.T.	$\frac{1}{2}$ to $1\frac{1}{4}$ in.
Polyorc BH	Water Chemicals Crude oil	High impact rigid *p.v.c.*, screwed union or plain socket for solvent welding 142	R.T.	$\frac{1}{2}$ to 2 in.
Polystantor	Water Chemicals	*Brass* compression fitting —	—	$\frac{1}{2}$ to $1\frac{1}{4}$ in.

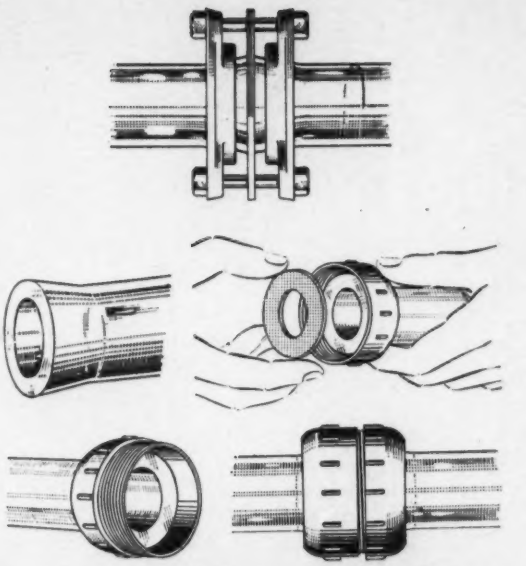
N.G.N. Electrical Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
(see *E.M. & D.* September issue, p.584)	Liquids	Screwed couplings		Nominal bore: $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$ and 2 in.

COUPLINGS FOR GLASS PIPES

Q.V.F. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
		Cast iron or *plastics* flanges		Bore of pipe:
	Chemicals	50	300	⅜ in.
	Food products	100		1 in.
		65		1¼ in.
	Laboratory wastes	50		2 in.
		40		3 in.
		35		4 in.
		25		6 in.
		15		9 in.
		10		12 in.
		6		18 in.
	(Precautions should be taken against thermal shock at temperatures in excess of 150°C.)			
Visible flow		*Plastics* couplings		
		—	—	



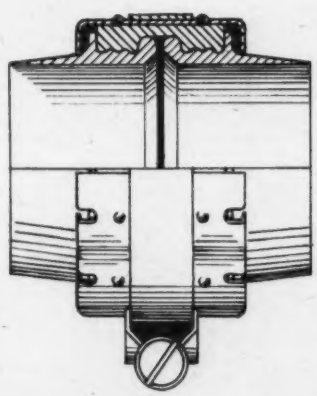
FLEXIBLE, SWIVEL AND ROTATING JOINTS

Aero Controls Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
ACFlex	Hydraulic Fuel Oil Air	Proof 250 (280 with air) Bursting strength 375	—50 to +70	o.d. of tube: ¼ to 4 in. Flexible coupling allowing angular and axial movement

Avimo Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Standard synthetic rubber sleeve	Water Fuel oil Coolant	450	100	o.d. of pipe: ¼ in.
		300		½ in.
		200		1 in.
		170		2 in.
		350	R.T.	3 in.
		400		¼ in.
		225		½ in.
		200		1 in.
				2 in.
				3 in.



ALUMINIUM COUPLING

Avica Equipment Ltd.

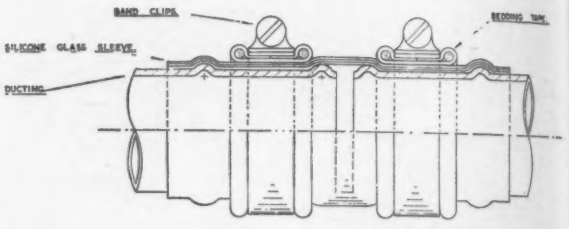
Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Avica-Flex Gimbal	Air Gas	Test pressure 250	450	Bore: 1 to 10 in.
Avica-Flex bellow assemblies		—	—	—

B.E.N. Patents Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
No. 135 hose connection	Air	*Brass* swivel connection		$\frac{1}{4}$ in. B.S.P.

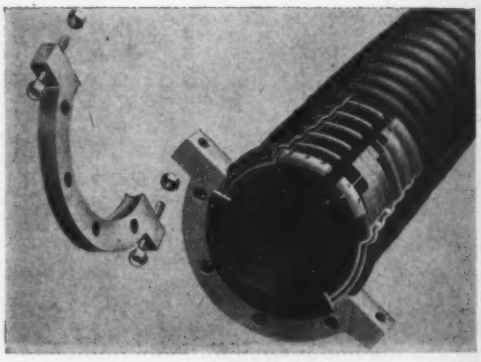
Bell's Asbestos & Engineering Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Silicone rubber and glass cloth ply construction	Air	—	—60 to +300	1 to 8 in. bore in $\frac{1}{8}$ in. increments.



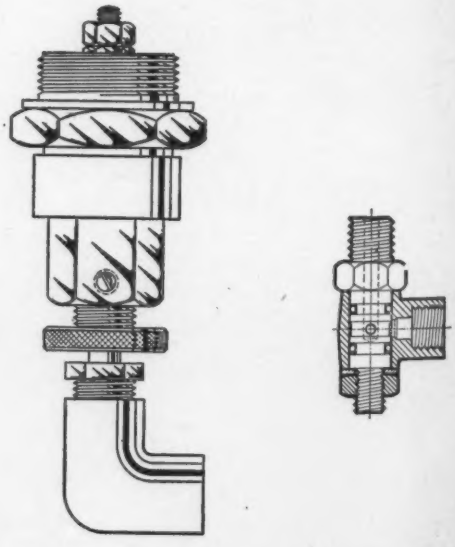
B.T.R. Industries Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Fulflex	Air	Integral flange and ring in wire reinforced hose		



Benton & Stone Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Hydraulics Air Gas Liquids	*Brass* rotating connection		
		100 at 2,000 r.p.m.	100	$\frac{3}{16}$ in. o.d. tubes
		100 at 500 r.p.m.	100	$\frac{3}{16}$ in. BSP. UNF and NPTF threads

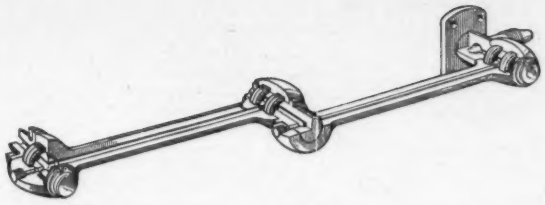


Consolidated Pneumatic Tool Co. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Schrader	Air	Screwed steel swivel 100	82	$\frac{1}{4}$ to $\frac{1}{2}$ in. hose

Electro-Hydraulics Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Hydraulics	Swivel coupling 4,000	—60 to +90	$\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$ in. BSP

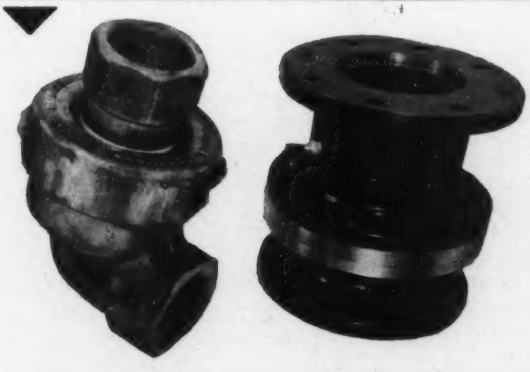


Filton Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Rotary couplings, all types	Air Gas Steam Oil	Maximum speed of rotation 1,000 r.p.m. Temperature limit 200°C.; with carbon bearings 300°C.		
Type RS		Rotary union with rotating centre tube		
Type ST		Rotary union with stationary centre tube		
Type BE		Rotary union with inlet only		
(Note: Types RE/RS RE/ST and RE/BE are replacing current types RS, ST and BE		Pressure limits for RS, ST and BE: 250 — 200 — 100 — 70 — 50 — 30 —		$\frac{1}{4}$ to $\frac{3}{4}$ in. 1 in. $1\frac{1}{4}$ in. $1\frac{1}{2}$ in. 2 in. $2\frac{1}{2}$ and 3 in. (All BSP)
Swivel coupling	Hydraulics	360° movement single-channel 1,250 —		$\frac{1}{8}$ to 2 in. BSP
		360° movement multi-channel 1,250 —		$\frac{1}{8}$ in. and upwards (designed to suit application)

J. R. H. Products & Co. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Steam Water Oil Chemicals	Standard swivel, 360° movement in *brass*, *gunmetal*, *steel* and *stainless steel* 300	250	$\frac{1}{4}$ to 2 in. BSP (T)
		Standard ball swivel, 360° movement; material as above with 20—30° angular flexibility 300	250	$\frac{3}{8}$ to $2\frac{1}{2}$ in. BSP(T)
Jayroc	Hydraulics Petrol Oil Gas Chemicals	Screwed or flanged swing-type swivel in *steel* or *stainless steel* 1,000 to 450	115	1 to 4 in. bore



Robert Harlow & Son Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Hydraulics	*Gunmetal* swivel coupling, single and double universal 100	220	$\frac{1}{2}$ to 2 in. BSP
		Gunmetal expansion joint, screwed or flanged 100	220	$\frac{1}{2}$ to 3 in. BSP nominal bore
		Cast iron expansion joint 100	220	2 to 6 in.

N.G.N. Electrical Ltd.

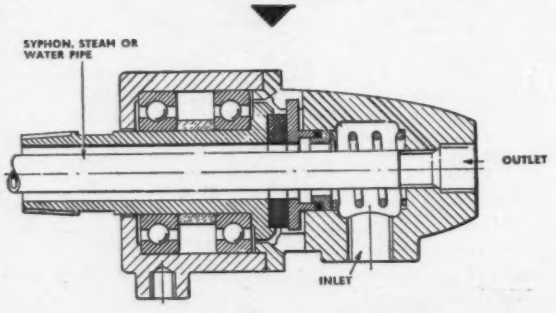
Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Vacuum	Flexible connection		Nominal bore: ¼ to 2 in.

Teddington Aircraft Controls Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Nuclear applications Chemicals Petroleum Gas Air	Bellow-type expansion units in *stainless steel*; other materials to order 10^{-6} vacuum	—200 to +1,000	Normal size ¼ to 72 in.

Weston Evans & Co. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
	Fluids	Ball bearing V-type rotary joint 160 at 500 r.p.m.	—	¼ to 3½ in. BSP(T)



Weatherhead Manufacturing Co. (England) Ltd.

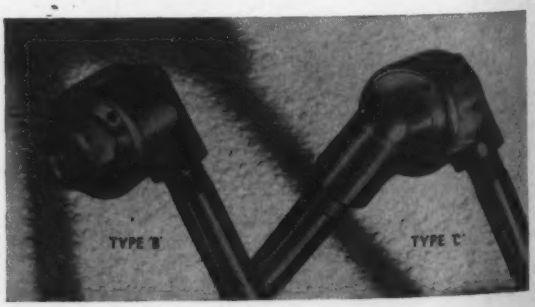
Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Weatherflex swivels	Mineral Hydraulic oil	*Steel* 4,000 (Higher values for specific applications)	—40 to +80	¼, ⅜ and ½ in. BSP

United Flexible Metallic Tubing Co. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Seamlex	Steam Water Air Vacuum	Rotary couplings: Type P, one-way; Type S, two-way with stationary syphon; Type R, two-way with revolving syphon 200 at 1,000 r.p.m.	198	¼ to 2 in. BSP(T) (also available with flanges)
Gyro	Steam Oil Air Water Gas	Horizontal or vertical coupling 180° movement 360° movement		¼ to 2 in. bore screwed BSP

The Victaulic Co. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Viking Johnson Junior		*Malleable cast iron* screwed non-mechanical coupling 150	82	Nominal bore ¼ to 2 in.
Viking Johnson	Water Gas Oil Air	*Steel* non-mechanical coupling; external sleeve with flange. Up to 1,000 depending on diameter		o.d. of pipe 2⅜ to 96 in.
Victaulic joints		*Malleable iron or rolled steel* Bolted clamp-type coupling up to 1,500	65	Nominal bore: 1½ to 72 in.
		Cast aluminium alloy up to 600	—	2 to 6 in.

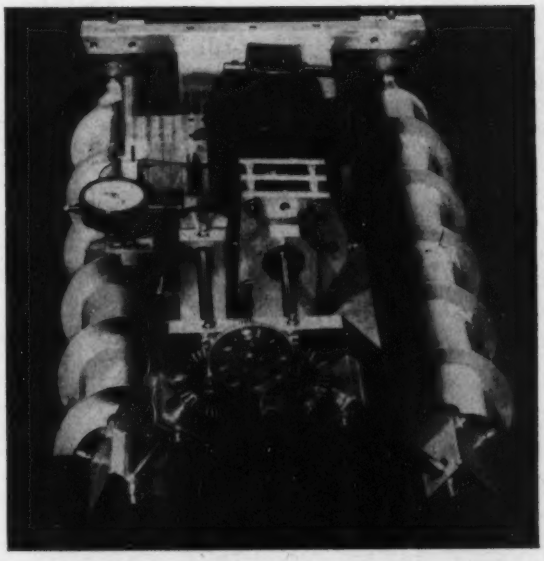


NEW IDEAS IN DESIGN

Outstanding products in current manufacture and awaiting development in the U.K.

The Archimedean Screw as a Traction Device

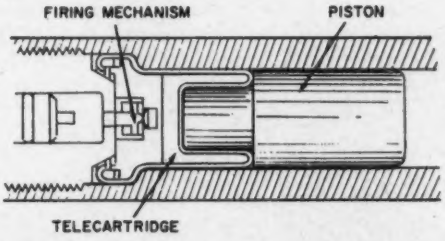
THE possibility of using two contra-rotating Archimedean screws as a means of propelling a vehicle across land and water formed the subject of a recent paper by B. N. Cole, Ph.D., Wh.Sch. A.M.I.Mech.E., Reader in Mechanical Engineering, University of Birmingham, which was presented recently to the Institution of Mechanical Engineers. The model shown, which was constructed in order to carry out some initial experiments only, on three pairs of long rotors, employs an aluminium chassis. The rotors are carried at a transverse centre line pitch of 11 in. and are rotated in opposite directions, inward at the top for normal forward travel. The total weight was about 42 lb., which varied slightly according to the configuration of the rotors used. The centre of gravity was arranged to fall slightly aft of the mid-length point of the rotors so as to prevent any possible tendency for the rotors to nose downwards into the sand bed in which the tests were carried out. The model was powered by a variable speed direct current motor, rated to give ¼ h.p. at 3,600 r.p.m. A reduction gearbox of 16/1 ratio was built on to the motor and the complete assembly was suspended between two self aligning ball race bearings, so as to act as a swinging field dynamometer.



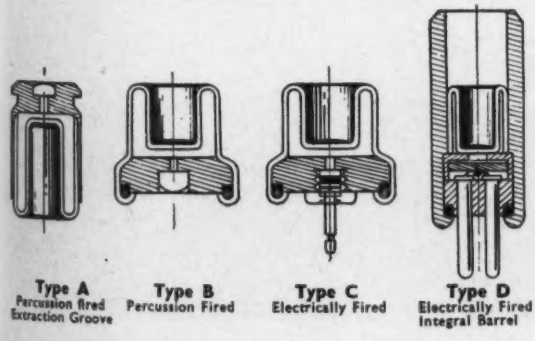
Although the investigation was only of a pilot nature having considerable limitations, it would seem that the proposed type of amphibious machine would be practicable and effective, either as a simple vehicle or as a tractor, when operating over soft terrains, but excluding hard and paved surfaces. It appeared that the great attraction of the idea is that it would provide a positive action when working in loose granular or semi-fluid grounds. A helix angle for the rotors of about 30 deg. seemed to give the best all round performance and greatest power economy for both aground and afloat conditions.

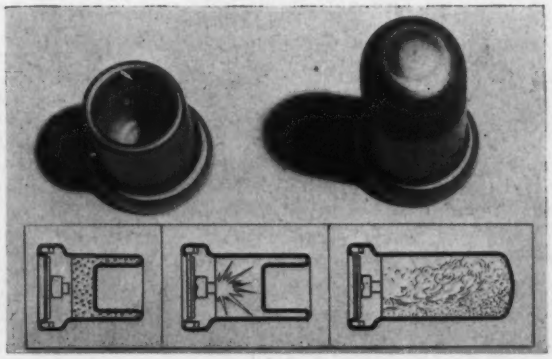
The Telecartridge, a Stored-energy Device

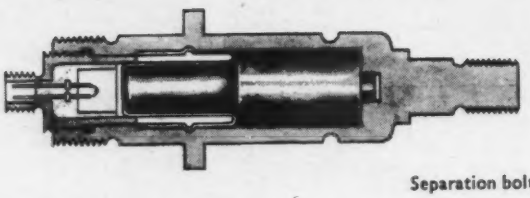
THE Telecartridge, a device produced by Aircraft Armaments Inc., is a sealed metal canister containing a propellent charge. The accompanying photograph and line drawings show the working principle. When the charge in the telescoped sheet metal container is ignited, the gas pressure produced causes the container to expand and so bring about a single actuating movement of great power. As the propellent gas-producing charge has an unlimited shelf life, these devices would appear to have considerable potential in fields other than those of aircraft and missiles, for which they were originally developed.



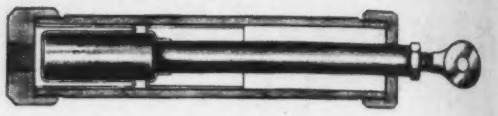
Telecartridges are said to be ideally adapted to the design of separation bolts for systems where the following charac-



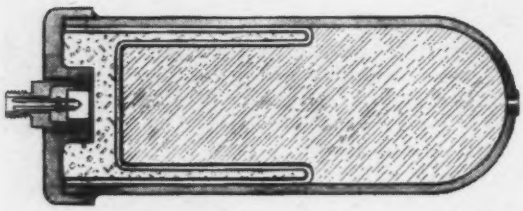




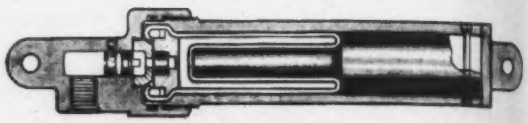
Separation bolt.



Actuator.



Dispenser.



Ejector.

teristics are required: elimination of fragments and hot gases; absence of flash, flame and smoke; and provision of thrust to aid rapid separation. Telecartridges can also be used as one-shot pneumatic or hydraulic actuators for operation at extremely high temperatures. In such cases either one or two folded containers can be used, one acting as a high-temperature seal which transmits the thrust to the actuator piston, the second acting as an energy absorber for velocity damping during the final portion of the stroke as it it deformed. Used in this kind of application, the expensive close tolerance machining associated with sliding seals is avoided.

Ejectors designed around Telecartridges obviate the expulsion of burning particles of propellent when the piston separates from the cylinder at the completion of the power stroke. Hot gas seals are thereby avoided, the gas is retained in the system and operation is quieter.

Telecartridges can also be used as a pressure-transmitting device for use with containers holding liquids, powders and pastes, without any risk of contamination by the actuating gas. Two reagents can be stored in a common container and then instantly mixed by actuating the Telecartridge.

Telecartridges can also be installed so as to operate from remote sources of high-pressure gas.

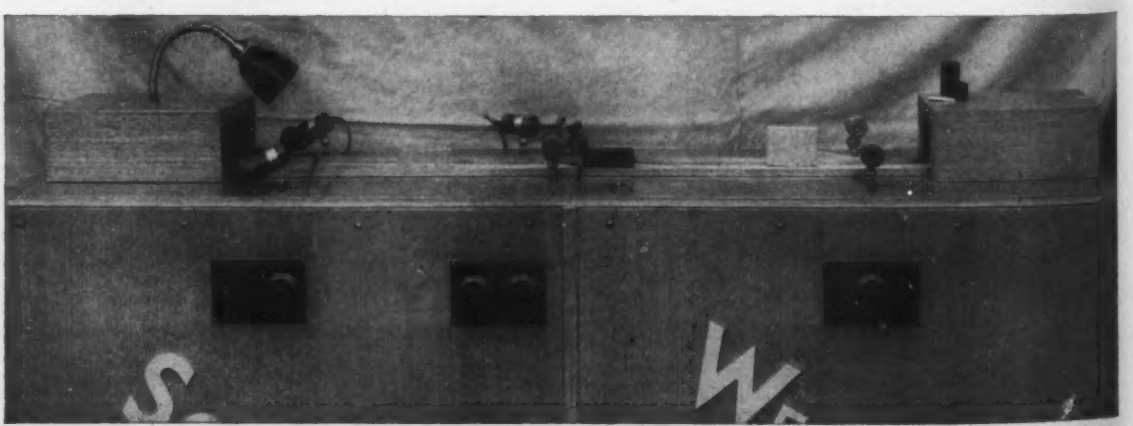
Ultrasonic Sensing and Switching System

WESTOOL Ltd. have announced a novel sensing and switching system, which uses an ultrasonic sound beam known as the Westool Sonac. The system is to be manufactured under licence from the Delavan Mfg. Co. of Iowa, U.S.A.

The system consists of three major parts: a control unit that contains a transistorized amplifier; a plug-in output relay and power supply; and two hermetically-sealed acoustic sensors. The two matched sensors convert electrical energy to ultrasonic energy and vice versa. One sensor acts as a transmitter, the other as a receiver. Electrical energy from the control unit is converted to ultrasonic energy by one sensor which emits a continuous ultrasonic beam. The second sensor receives the beam and converts the ultrasonic waves to electrical energy which in turn is sent back to the control unit, thus providing circulation around a closed loop.

The advantages claimed for the system are that it has a long life, and provides a dependable service with a flexible performance. The circuits are completely transistorised, and the sensors are of hermetically-sealed pod construction which ensures long life. There are no bulbs or tubes to wear out, and the system is said to be unaffected by ambient light, dust, industrial contamination, steam, smoke and vibration. The acoustic beam is invisible and inaudible.

The Westool Sonac system can detect solids or liquids, opaque or transparent objects, and ferrous or non-ferrous



metals. The objects to be detected can be fast or slow moving at a wide range of distances. The beam can be made several feet wide or will work through holes down to about 0.03 in. dia., and the sensors can be concealed or remotely located. A noteworthy feature of the system is that the ultrasonic beam can be conveyed to the work area by means of flexible tubing.

The system can be used in four basic ways. First, the sensors can be installed to provide a direct path in which an obstruction between the sensors breaks the acoustic path, thereby de-energising the output relay. The relay operates the desired external function (light, buzzer, switch, etc.). Although ultrasonic waves are transmitted from one sensor to the other sensor at approximately a 50° angle, an object large enough to cover the active area of the second sensor will break the beam for short path lengths.

Secondly, the direct path method can also be used to sense the removal of an object from the beam. With the object obstructing the beam, the output relay is de-energised. When the object is removed the acoustic path is completed, and the relay energised.

The third and fourth ways in which the system can be used are with sensors located so as to provide a reflective path. As with the direct path, the reflective beam can also be used in two ways: with the relay energised to sense objects, or with the relay de-energised to sense the removal of objects from the beam. In this method the sound waves emitted from one sensor are reflected from an object to the second sensor to provide the acoustic path. When the object is removed from the path, the relay is de-energised. Conversely, when objects establish a path the relay is energised. The reflection method is said to be particularly advantageous for counting or sensing small objects.

A specially built demonstration unit which illustrates the operation of Sonac is shown at the foot of the facing page. Three Sonac units are fitted along a continuous belt. The first (from the right) is counting boxes in very dusty and dirty conditions simulated by a dust sprayer fitted beside the belt. The second Sonac is sensing for height. When a box passes which is higher than the others on the belt the beam actuates a solenoid which knocks the box down. The third is counting boxes under a flashing light.

Electromagnetic High-speed Press

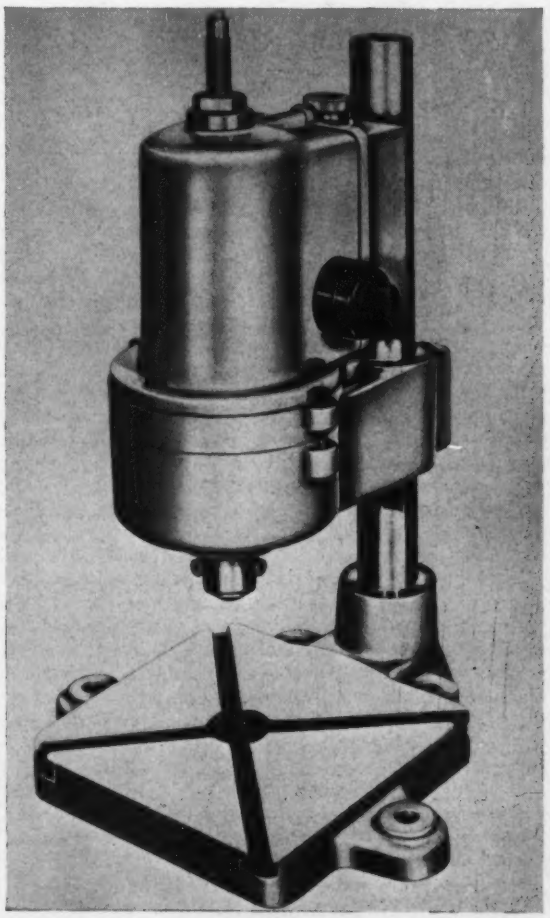
THE IMR Press, recently introduced by H. G. Stevens Co. Ltd. is a compact solenoid-operated machine having only one major moving part. The press power head is mounted on a stand, and its height is adjustable. For special-purpose applications the head may be supplied without the stand, as the mechanism is said to work equally well in any direction, even vertically upwards.

The capacity of the IMR is up to 3½ tons, the stroke rate being variable from about 20 strokes/min. up to a maximum of 200, or it can be set for single stroking. The impact force is infinitely variable from 7,500 lb. down to about 650 lb. Length of stroke is 2½ in., and table size 10 × 10 in. The net weight of the press is 160 lb.

Novel features claimed for the machine are ease of adjustment of the impact load, robustness of the speed control unit, and the rapidity with which tools may be changed and set up again. For light-duty bending, riveting, staking, embossing, forming, blanking, etc., the IMR would appear to offer advantages over the conventional fly press or kick press, particularly where a great variety of operations must be performed.

The IMR press can be operated from any single-phase supply from 220 to 250 volts, and is supplied complete with energising rectifier and controls, which can be double push-button or pedal operated. The input current rating is 5 amps., the actual power consumption 50 to 200 watts, and the rectifier output voltage 170 volts d.c.

The press should be of interest not only to all engaged on light metal forming, but also to manufacturers of leather, plastics or cardboard items. It should also benefit firms with a great variety of operations to perform and who wish to replace a whole range of less versatile devices and to standardise on a single model press.



DESIGN OF VISUAL INDICATORS: PART 2

In this second and concluding part of his article the author deals with the design of qualitative moving-scale indicators, and also summarises the aspects dealt with in Part I

by JOHN SPENCER, M.A.*

Qualitative Moving-scale Indicator

The requirements here follow exactly those described for the fixed scale type in nearly every case. Thus dimensioning of scale, marks and legend, as well as scale graduation and number system, will remain unaltered. Some differences and additional features arise, however.

It was mentioned previously that moving scale indicators provide a possible solution to problems involving non-linear scaling. Before considering this point it should be realised that when interpolation is necessary during scale reading, then a linear scale should be provided if at all possible. Human beings have considerable difficulty in interpolating positions on non-linear scales. If it is impossible to provide linear scaling, and either a moving pointer or moving scale indicator must be used, then the latter will be preferable. This is because most of the scale can be masked so that what is visible is reasonably linear in appearance. Even then the error tolerance will vary along the scale, so the scale length will have to be chosen to give the desired error tolerance in the critical part of the scale. The simplest solution if other considerations allow is to use a counter indicator.

An additional feature to consider is the length of visible scale. The window must be wide enough to expose three numbered major marks when the centre one of the three is opposite the index. This ensures that the direction of number increase is always shown. It has been mentioned that to provide correct direction of movement relationships the numbering system should increase to the left, or downwards, or anti-clockwise. Since this conflicts with the convention for fixed scale indicators, the clear recognition of numbering direction is imperative. With non-linear scales, ideally the window width should change for different parts of the scale. Where this is technically possible it would be valuable.

A point to watch with moving scales viewed through windows is "tunnelling", which can seriously reduce dial surface illumination. A translucent white mask or internal lighting should solve this problem.

*Department of Psychology, University of Bristol.

Counter Design

Although offering a very neat solution to many quantitative information display problems, the counter has some drawbacks. The first of these is the lack of rate of change information provided. The unit digits become a grey blur for all but the slowest rates of change. Secondly, numbers have a remarkable family likeness, so that 6546, for example, looks very much like 6456 at a casual glance. Thus by itself the counter is poor for check reading purposes, unless it displays only two or three digits.

It is therefore safer to regard a counter as only part of an indicator, the rest of which is provided by the designer to overcome the two difficulties experienced by human beings when reading and remembering strings of digits. These difficulties are not so much due to visual inadequacies, as to intellectual or mental inadequacy in handling this sort of information. Human short-term memory is un-

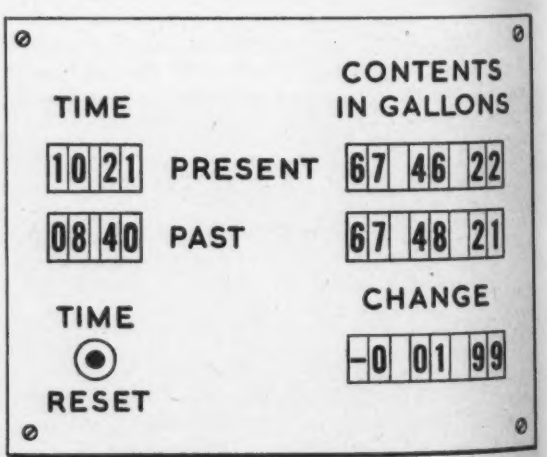


Fig. 10. Memory-assisted counter display (hypothetical).

reliable under favourable circumstances, and for mere numbers it is, by computer standards, appalling. An average value for the number of digits that can be repeated back immediately after receipt of the information is six or seven. And when carried out repeatedly, as in observing sequences of counter indicators this figure falls, due to memory interference effects from preceding groups, so that a safe upper limit to use is probably about four digits. If counters carrying more digits than this are envisaged then some form of memory assistance must be provided. Since no experimental work exists yet on this topic, it is only possible to make suggestions on ways of providing this assistance. Where the indicator is used purely for logging purposes, then memory assistance is probably unnecessary. In continuous control situations the most direct help takes the form of difference indications showing by how much the present indication differs from some pre-set value. The pre-set value can of course be either a future target, a constant level or a past-time level. In other cases it will be better to show the present and some pre-set target value in full rather than show a difference value, but it is essential to provide clear differentiation between the two values, so that a response will not be made to the target value in mistake for the present value. An imaginary display of this sort is illustrated in Fig. 10.

The form and dimensioning of the digits can follow those already suggested. However, the digit dimensions can probably be increased with advantage to give the indicator more weight on a panel, since it otherwise might not be very conspicuous. This will be less necessary if the counter indicator is a composite unit of the sort shown in Fig. 10. To ensure that the digits remain the focus of attention it will be beneficial to increase their height by about 25% over that of the accompanying label lettering, which itself should be of correct height for the observation distance.

Where several digits have to be used, both perception and memory will be assisted by grouping digits into pairs as shown in Fig. 10. In any case the spacing between adjacent digits should be increased in proportion to the number of digits displayed.

The local area of the counter should be treated much like other indicators on the panel as regards colouring. That is to say the immediate area should be the same as that of fixed or moving scale indicator dials, and a painted surround should frame the unit and its labelling. This prevents the counter indicator from being "a small hole through which you can see some figures", and from being the rather inconspicuous display that it tends by nature to be. A final obvious point is that the digits should change abruptly from one position to the next.

General Observations on the Design of Qualitative and Representational Indicators

There is much less to offer in the way of concrete information about these two classes of indicator, and some of what might be said has already appeared earlier. But there are some fundamental points that apply to both classes which should be stated.

The first and most vital is that the smallest indicator change to which the observer must respond should be clearly visible. In the case of quantitative indicators this change is nearly always one of position, either of a pointer or a scale or a digit. But with the indicators now being discussed there is no need for this restriction. Any visually detectable change can be employed in the interest of variety and realism: colour, shape, area, length or brightness, for example. As long as the minimum significant change is clearly visible any of these can be used.

The second and equally important feature is the provision of a reference against which the change can be judged. This is in effect a sensory magnifying process, because comparative judgments are very much more sensitive than absolute judgments. This can be simply illustrated by experimental evidence on colour discrimination. When two areas of colour are simultaneously compared one with the other the average observer can divide the visible spectrum into between 150 and 200 different discriminable hues. But when faced with the absolute recognition of a single colour the average observer is reduced to a reliable recognition of between eight and ten hues. So it is perhaps no accident that the rainbow is traditionally described as containing seven colours. A similar phenomenon occurs with the detection of brightness changes. The human visual system is beautifully adapted to the detection of simultaneous differences, and very ill-adapted to the detection of changes occurring over time unless these are converted to a simultaneous difference by the provision of a reference indication.

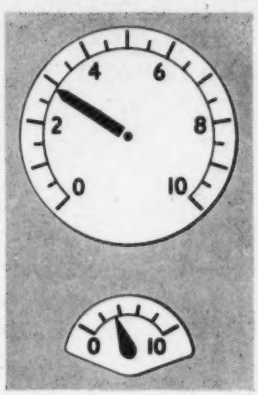


Fig. 11. The acceptance of reduced reading accuracy can give considerable savings in indicator size. The two indicators shown are designed for the same observation distance but the upper indicator is scaled to give ±1% of M.S.V. reading accuracy, while the lower indicator is scaled to give ±5% of M.S.V. reading accuracy.

The third point, already discussed, is whether to provide subjective or objective reference information. It arises chiefly in indicators for transport systems, and other cases which involve changing spatial relations.

It now remains to describe some further points relating to either qualititative or representational indicators, to complete the discussion.

Qualitative Indicators

Whereas the quantitative indicator defines a particular value along a continuum, the qualitative indicator defines one of several arbitrarily chosen ranges along a continuum. For example, a voltmeter may be used to measure the potential difference across a battery. The qualitative equivalent is a meter scaled "flat—low—normal—high". This reasoning can be carried further by regarding the arbitrary ranges as being defined by the observer's error tolerance. One can then regard a ±10% quantitative indicator as a qualitative indicator for rapid checking purposes. The advantage of this approach is that much smaller, simpler scales can be used, and an additional differentiation on panels is achieved in such a way that size differences are meaningful—the critical indicators are the larger members of the panel. Fig. 11 illustrates this application of low accuracy quantitative scales for qualitative indicator use.

The design possibilities with this class of indicator increase enormously, so that few specific suggestions can be made. However, one general approach seems well worth exploring, both for this and the next class to be described—this is the use of dynamic indicators. In all the indicators so far discussed the observation is made on a stationary

or essentially static display. But the periphery of the visual field of the eye is well adapted to detecting movements. Also, moving patterns often make vividly easy the detection of minute changes in speed of one of the components when seen with central vision. The rotating "barber's pole" which is used to assist the pilot of an aircraft is a good example of the first of these possibilities. Any indicator on these lines will of course require careful trials, to check that prolonged operation in the user's field of view does not give rise to annoying visual after-effects of the seen-movement. However, for short periods of operation in some critical phase of a control task this is unlikely to cause difficulty.

The simplest of all qualitative indicators is the two-state display. An obvious design feature to incorporate here is a positive indication for each state in situations where failure of a flag mechanism or a bulb can lead to a false impression that all is normal. Car braking lights are a good example, where absence of the positive indication may or may not mean that the vehicle is braking in front of you. Fail-safe warning indicators will correct this defect to some extent.

Representational Indicators

This class, more than either of the previous two, raises problems that are predominantly caused by the need for knowledge about the interpretative mechanism of the brain, rather than by the needs of the visual system. To know how to model or represent a system implies that one knows what to model, and it is knowing what to model that matters. Much more needs to be discovered about the ways in which the human brain builds up its picture of the external world, particularly those specialised and highly technical "worlds" that occur in industry.

One certain point is that the designer's "model" of a system will nearly always be very different from that of the people who have to use the system. And in the vast majority of cases there is no reason why they should be the same. The designer must know the underlying physical principles and laws of the system he is designing. But the user or operator has no real reason for interest in the designer's explanation of the system. Instead, his interest lies in the relations between levers, switches, valves and indicators. It is possible in some cases for the indication of something relatively secondary in the designer's view to be of immense benefit to the user, because it helps him to organise or schematise his mental model more readily or rapidly. This is not much to ask when one considers the time and effort spent providing a computer with the sort of model it requires in order to do its job.

Direct representation of a system is not necessarily the best basis for a representational indicator, particularly if a lot of information is included which the user can do nothing about. When designing control systems which involve human operators, the engineer employs a transfer-function to represent the operator in the calculations. Although obviously a gross over-simplification of an operator, this is satisfactory provided it gives an adequate solution to the engineer's problem. In exactly the same way, the user of a representational indicator will be content with a representation that is very much over-simplified so long as he can maintain control and comprehension of the events that directly concern him. Unfortunately it is not always easy to decide what constitutes the best "transfer-function" of the system to display to the user. Perhaps the safest suggestion for the general case is that the initial representation should be over-simplified. Then by progressive addition and modification with experimental validation at each stage, an approach can be made to the final best design.

To give some substance to the preceding remarks an example will be considered. This problem is that of the human control of traffic flow at the junction of several major roads. An essential feature is that control should be adaptable to rapid flow changes — minute-to-minute changes, and daily, weekly and seasonal changes. It is assumed that the junction is too large physically to be covered directly by one man. Therefore it is specified that he should be in a small control room or cabin where protection from bad weather, and comfort for lengthy spells of control, can be achieved. The controller's decisions should be executed by a system of traffic lights. The use of quantitative indicators for every variable in the situation is ruled out, because the number of indicators requiring rapid assimilation would be excessive at a large junction, and because a lot of calculation would be left to the controller. The requirement here is for a display which "ties the total situation together" by its nature instead of leaving it to the user, and which does the arithmetical donkey-work, thus leaving the controller free to make overall evaluations in making his decisions.

The most complete representation of the situation is probably a vertical television picture of the whole junction and the roads leading to it, from about a mile inwards. Such a display would include a lot of irrelevant information, and would not be very practicable at night, but the idea of a plan representation is a good one for creating the unity that this kind of display must suggest.

In addition to those already mentioned, two further indicator requirements are that the quantitative aspects of the situation should be displayed, and that the display be "ahead of time". The first of these requirements is necessary if the controller is to make the best flow decisions. The second is necessary in order to give him time to make a decision and also to watch a situation develop before having to make a final decision. It is well known that difficulty and decision time are positively related, but the optimum "time ahead" for the display requires experimental determination. Possibly it is best included as a variable adjustment to suit different controllers and traffic situations.

The proposed display is shown in Fig. 12 for the case of four routes meeting at a junction. The coloured bars now form the plan representation. The indication for each route is formed by a superimposition of two projected coloured images, one red and the other a complementary green-blue. The width of each image on the translucent display screen is proportional to the number of vehicles predicted to enter or leave the junction within the period of time covered by the prediction. As arranged in the illustration, the red image width is proportional to the predicted number of entering vehicles, and the green-blue image width proportional to the predicted number of outgoing vehicles on available exit routes.

In the case where the superimposed images are of equal width (i.e. inflow=outflow) a white bar of light is generated for the route concerned. If more vehicles enter than can exit by other available routes in the prediction period then a white band with red borders is generated. Thus the quantifiable aspects of the problems are displayed as linear distances, so that a glance appreciation of the route carrying the heaviest flow of traffic can be gained by comparing the white widths for the routes displayed. And the colour and width of the edges show which routes are loading the junction too much or relieving the traffic load, and by how much in each case.

The lights at the junction end of each route give an indication of vehicle presence and speed. They would be operated by contact strips across the inflow lanes at the junction, and would remain on for stationary vehicles, flash

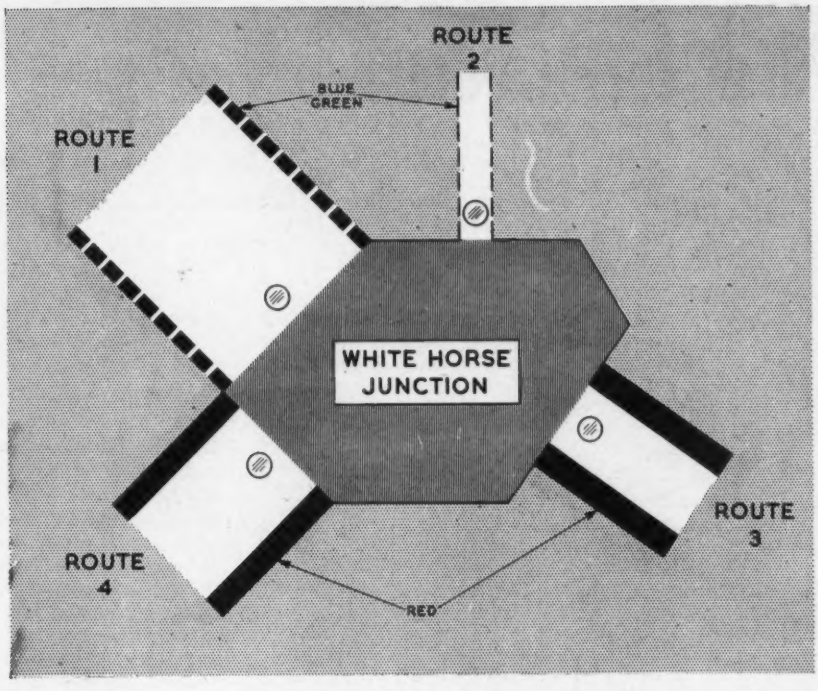


Fig. 12. Representational display for traffic control. Traffic flow conditions corresponding to the display are shown in the following Table.

Route	TRAFFIC (No. of vehicles travelling) Inwards	Outwards
1	600	10
2	100	160
3	400	700
4	500	500

at a rate roughly proportional to vehicle speed, and remain off when no vehicles were entering the junction. They are essential to this display conception, because stationary queues would be displayed as "no vehicles entering the junction" by the projected images. This would not be very popular.

The problem of generating the display variables is an engineering one, and involves making various assumptions about traffic flow. In the present example it is assumed that it is possible to measure the number of vehicles entering and leaving the junction per unit time by each route at a point about half to three-quarters of a mile from the junction. It is assumed that the rate figures for entering traffic can be integrated over a duration equal to the prediction period, and these values used to generate the red image widths for each of the appropriate routes. It is further assumed that simple arithmetic operations can be performed on the inflow-outflow values to generate the green-blue image width, as follows.

The formula used to calculate the green-blue image width is:

Available outflow for traffic entering junction on route 1

$$=O_2\left\{1-\frac{\Sigma I-(I_1+I_2)}{\Sigma I-I_2}\right\}+O_3\left\{1-\frac{\Sigma I-(I_1+I_3)}{\Sigma I-I_3}\right\}$$

$$+O_4\left\{1-\frac{\Sigma I-(I_1+I_4)}{\Sigma I-I_4}\right\}$$

where O_1, O_2, etc., represent numbers of vehicles leaving the junction by routes 1, 2, etc.; and I_1, I_2, etc., represent numbers of vehicles entering junction by routes 1, 2, etc. A more suitable formulation might be to relate predicted numbers to the maximum capacities of the routes, if it is possible theoretically to calculate maximum capacities. But the formula used seems better, in spite of its pitfalls, because it measures available out-flow in terms of what is actually happening rather than what might happen.

The final assumption is that where the distribution of the predicted values is non-normal, then some form of transformation can be applied so that the display approximates reasonably to an average condition for the prediction period.

Because of the variety of possible non-conflicting flow routes in large junctions, the controls used by the controller are reduced to one master button for each route. When this is pressed, interlocks operate which automatically give green lights to the route selected, and to any other routes which will not cause crossing traffic for the selected principal route.

Although the problem has been very much over-simplified, it gives some idea of a starting point for the solution of a case where a representational indicator is regarded as the best type of indicator to employ.

The preceding paragraphs represent a brief survey of a wide field. Although there is no lack of experimental evidence, there are still many unsolved issues and untouched aspects of the problems of providing people with useful and usable indicators. Consequently, what has been written is a starting point for further investigation, for which the impetus will almost certainly come from the designer. And for the designer, it is hoped that the article will provide, if not impetus, then a gentle push in the direction of novelty and innovation, for which there is enormous scope. More and more people spend a proportion of their time examining collections of "clocks", and as our knowledge grows the standardization of these is becoming greater—hence they tend to look more alike. But a crowd of people is interesting in proportion to the diversity of its members. It is up to the designer to see that the same applies to the crowds which gather on instrument panels, so that diversity is due to function, not to mere fancy. We will then be, as the Americans might say, more "clock-wise".

Correction to Part 1, published last month: the captions to the two top rows of digits in Fig. 8, on page 574, were inadvertently transposed (i.e. the top row is Granby Bold).

NEW SOLAR POWER DEVICE

A new energy-storing device developed by Boeing Airplane Co. is expected to provide more efficient solar-to-electric energy conversion. Research to reduce high internal resistance should result in higher maximum power per unit electrode area

A NEW two-stage device for converting solar energy into electrical energy promises operating efficiencies comparable with current photovoltaic devices—and acts as its own storage battery. The first stage will convert solar to chemical energy by the photochemical isomerisation of trans to cis organic acids (cis and trans indicate two forms of geometrical isomer). The next stage converts chemical to electrical energy by means of electrochemical concentration cells. Concentration cells using cis and trans acids have been constructed, and potentials approaching the theoretical value of about 0·1 volt measured. The maximum electrical power measured in the various systems was 2-3 microwatts/sq. cm. of electrode area, despite high internal resistances. Techniques for reducing these resistances are being investigated.

Ultraviolet radiation causes geometrical isomers to change from one molecular configuration to another. The photostationary state of the isomers (that is, the equilibrium concentration of the cis and trans forms under ultraviolet illumination) favours the cis form. As the cis form is thermodynamically less stable, some of the radiant energy is stored as chemical energy.

The next step is to recover the stored chemical energy in an electrochemical manner. If two solutions containing the same ion at different concentrations are connected by an ion bridge, a potential difference exists as a result of the concentration difference. Such an electro-chemical cell is known as a concentration cell.

Table 1 shows the various physical properties of cis and trans acids that are of interest in the proposed electrochemical mechanism. The cis-isomer is always much more soluble than the trans-isomer, and it also has a higher dissociation constant. Both the cis and trans acids will ionise in water to give hydrogen ions. However, because of the differences in the dissociation constants and solubilities, there will be more hydrogen ions in a saturated cis-acid solution than in the corresponding trans-acid solution. Therefore a potential difference will exist between saturated cis-acid and trans-acid solutions when these are connected by an ion bridge.

Using the data in Table 1, cells composed of saturated solutions of the various cis-trans isomers would have theoretical potentials as follows: maleic-fumaric 0·095 volts; citraconic-mesaconic, 0·083 volts; cistrans cinnamic, 0·095 volts. Experimental cells of the first two systems have been constructed.

Table 1. Physical properties of various cis-trans acids

	Molecular Weight	Dissociation Constant	Solubility at 25° C. (molality)
Maleic acid	116	$1{\cdot}15\times10^{-2}$	6·72
Fumaric acid	116	$9{\cdot}1\times10^{-4}$	0·06
Citraconic acid	130	$3{\cdot}33\times10^{-3}$	27·7
Mesaconic acid	130	$7{\cdot}75\times10^{-4}$	0·21
Cis-cinnamic acid	148	$1{\cdot}32\times10^{-4}$	1·12
Trans-cinnamic acid	148	$3{\cdot}7\times10^{-5}$	0·0027
Angelic acid	100	$4{\cdot}9\times10^{-5}$	To be determined
Tiglic acid	100	$9{\cdot}4\times10^{-6}$	To be determined

Construction of the Concentration Cell

Fig. 1 shows the proposed solar concentration cell. In the operation of the cell, both sides would be filled with a saturated solution of the trans acid. A large excess of the solid trans acid is placed inside *A*, and this side is exposed to the incident radiation while side *B* is shielded.

The dissolved trans-acid on side *A* is changed photochemically into the cis form of the acid, resulting in the

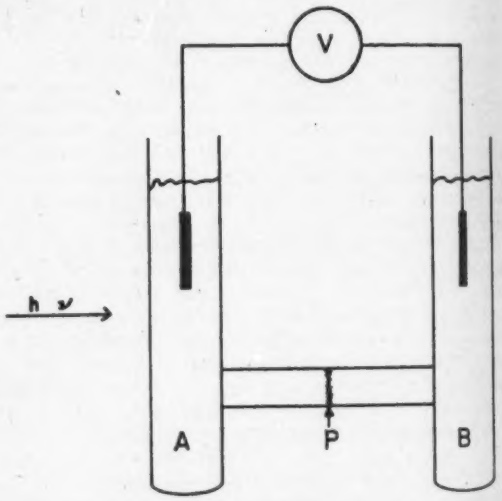


Fig. 1. Proposed solar concentration cell. Side *A* is exposed to incident radiation ($h\nu=E$, where E is the energy of each quantum of light of frequency ν, and h is Planck's constant). Side *B* is shielded; *P* is a porous disc.

solution of more and more of the solid trans acid. It has been verified experimentally that, even in an unstirred solution, a large dissolution of the solid trans acids occurs in saturated solutions of trans acid under the influence of ultraviolet light. This indicates conversion to the cis form and subsequent dissolution.

The trans-to-cis isomerisation occurs whether or not current is being drawn from the cell. In fact the longer the cell is irradiated before power is drawn from it, the larger the power that is available. Provided the cell is "charged" during a period of daylight, current may be drawn in either periods of daylight or darkness.

Experimental concentration cells identical to that shown in Fig. 1 have been constructed. Because they were made of Pyrex glass, which is opaque to ultraviolet radiation,

Table 2. E.M.F. of cis-trans concentration cells

System	Concentration of cis-acid, molality	Concentration of Trans-Acid molality	Concentration of KCL	Theoretical E.M.F. (volts)	Experimental E.M.F. (volts)
Maleic-fumaric acid	0·060	0·060	—	0·033	0·006
Maleic-fumaric acid	0·060	0·060	1N	0·033	0·035
Maleic-fumaric acid	0·060	0·060	2N	0·033	0·035
Maleic-fumaric acid	6·72	0·060	—	0·095	0·010
Maleic-fumaric acid	6·72	0·060	1N	0·095	0·111
Citraconic-masaconic acid	0·21	0·21	—	0·019	0·.002
Citraconic-masaconic acid	0·21	0·21	1N	0·019	0·024
Citraconic-masaconic acid	27·7	0·21	—	0·83	0·008
Citraconic-masaconic acid	27·7	0·21	1N	0·083	0·100

photochemical conversions were not carried out in them. They were filled with various concentrations of cis and trans acids. Open circuit voltages were measured; Table 2 shows the results. In the cases where the inert salt potassium chloride was added, the potentials were equal to or greater than the theoretical values calculated by equation. The potentials greater than the theoretical values calculated by equation probably indicate the solutions are not ideal (activites should be used in place of concentrations). Errors in reported solubilities could also explain these results; or the liquid junction potential may be responsible. However, the presence of potassium chloride makes the latter alternative seem remote. It is felt that the potassium chloride functions only to lower the internal resistance.

Table 3 shows the heat of isomerisation of the various cis-trans systems, together with the calculated maximum wavelength of incident radiation necessary to promote the isomerisation. Note that the maximum wavelengths necessary to promote the trans-to-cis isomerisation in these compounds occur in the infra-red region of the spectrum, while all experimental investigations have been conducted in the higher energy ultraviolet region. There is no apparent reason for the reaction not proceeding in visible light; for the acids indicated, the probable reason that the trans-cis isomerisations have not been observed is that the solutions are transparent in this spectral region. Research aimed at finding a photosensitiser to cause the cis-trans isomerisation to occur in the visible region of the spectrum is being carried out.

The amount of chemical energy available from saturated solutions of cis and trans acids is given by the free energy of isomerisation. These are approximately equal to the heats of isomerisation shown in Table 3. Maximum efficiencies for the conversion of chemical energy to electrical energy have been calculated, and are also shown in Table 3. These efficiencies are comparable to the maximum efficiency calculations for most heat engines.

The experimental concentration cells were operated at various external resistances in order to determine the maximum power per unit electrode area. Figs. 2 and 3 show the results for saturated maleic-fumaric acids in one normal potassium chloride, and for saturated citraconic-mesaconic acids in one normal potassium chloride. Maximum in the curves corresponds to the maximum power obtainable from the particular system. These curves substantiate what can be proved theoretically—that the maximum power occurs

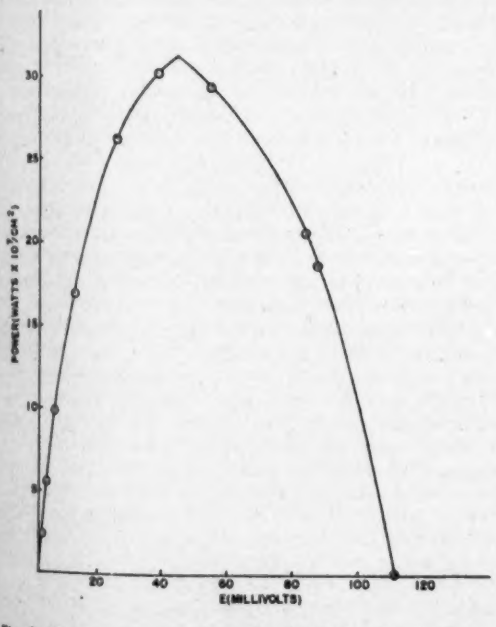


Fig. 2. Power-voltage curve for a saturated maleic-fumaric acid system in one normal potassium chloride.

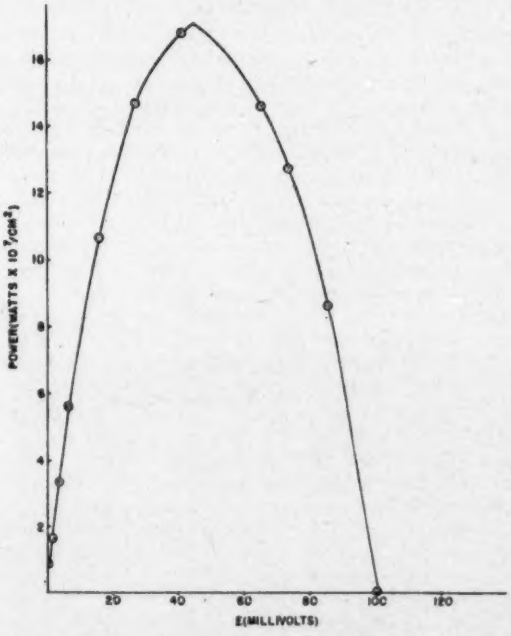


Fig. 3. Power-voltage curve for a saturated citraconic mesaconic acid system in one normal potassium chloride.

at the point where the external resistance equals the internal resistance.

Despite the fact that these concentration cells contained a large amount of inert salt, the internal resistances were large—about 800 ohms in the maleic-fumaric, and about 1,200 ohms in the citra-conic-mesaconic system. The most probable cause of the high internal resistance is the existence of the porous disc separating the two half cells. In all of the experiments reported, the disc was of "fine" porosity; however, experiments using discs of different porosity are contemplated. Another way of separating the two half cells and greatly lowering the internal resistance would be to use an anion permeable to maleate ions alone; thereby such a low internal resistance separator would also reduce thermal diffusion losses to zero. If the internal resistance of the concentration cell can be lowered, the maximum power per unit electrode area can be very considerably increased.

While Figs. 2 and 3 indicate power per unit electrode area, this should not be confused with the geometrical size of the electrode or the area of the solution exposed to the incident radiation. It is possible to obtain physically small electrodes possessing very high surface area, and these electrodes need not be exposed to the radiation for the operation of the cell. From the standpoint of ultimate power, the important factor is the total radiation absorbed by the cell solution. This is a function of the exposed solution area, light intensity, solution absorptivity and length of the absorption path. All of these factors may be varied at will by appropriate means.

Table 3. Energy relationships in cis-trans acid systems

System	Heat of isomerization (kcal·/mole)	Maximum wave length[1] (angstroms)	Maximum wave length[2] (angstroms)	Maximum Electrochemical efficiency (%)
Maleic-fumaric acids	6·1	46,800	10,900	35·6
Citraconic-masaconic acids	2·7	105,500	12,600	70·5
Cis-trans cinnamic acids	6·8	42,000	10,600	32·0
Tiglic-angelic acids	8·4	33,900	10,000	—

[1] *No activation energy is assumed* [2] *Activation energy of 20 kcal /mole assumed*

NEW MATERIALS IN THE CABLE INDUSTRY

IT is difficult to classify precisely what is covered by the term "new materials", but it can be said that the following have only come into commercial production during the past decade.

Polytetrafluoroethylene

P.t.f.e. is an organic material which will operate up to 250 deg. C. without deterioration. It is non-inflammable and both chemical and solvent resistant. It has low permittivity, low power factor and high insulation resistance, and is used mainly as an insulant for aircraft equipment wiring, for which its unique properties are ideally suited. Unlike polythene and other plastics materials, p.t.f.e. does not melt and cannot therefore be extruded on a conventional extruder. A special design of machine is used, which is manufactured by Jennings Engineering (Great Britain) Ltd. In this machine, p.t.f.e. previously lubricated is extruded onto the conductor. It is then passed through a chamber to evaporate the lubricant, and through a second high-temperature chamber where the p.t.f.e. insulation is sintered into a solid homogeneous covering.

Alternatively, the p.t.f.e. insulation can be applied by lapping unsintered tape onto the wire and then passing it through a high-temperature chamber to seal the overlap and sinter the material.

Polyethyleneterephthalate

This is another organic material having excellent mechanical and heat-resisting properties. It can be applied in the form of woven tape impregnated with silicone varnish, and can be used in all types of cable where varnished cambric has been used hitherto. Because of its improved mechanical properties, thinner insulation thicknesses can be used coupled with a higher maximum operating temperature, 130 deg. C. against 80 deg. C. for varnished cambric. It can also be applied in the form of thin film, and tapes only 0.001 in. thick have adequate strength to serve as a non-hygroscopic binder in plastics mains cables. On high-temperature aircraft cables, it is applied both in tape form and as a woven braid to provide resistance to abrasion and the ingress of aircraft fluids.

Butyl Rubber

This is a copolymer of isobutylene and isoprene—the former predominating, but enough of the latter being present to give good vulcanising properties. Butyl rubber compounds have all the attributes of natural rubber compounds, but have improved temperature performance and impermeability to air and moisture. Butyl rubber insulated cables can operate up to conductor temperatures of 85 deg. C., compared with 60 deg. C. for rubber cables and 80 deg. C. for varnished cambric cables.

M.i.n.d. Compound

This is used for the impregnation of paper cables which are to be installed vertically or in steeply inclined situations, where the insulant is required to have non-draining properties. M.i.n.d. (mass impregnated non-draining) compound is basically a mineral oil gelled by the addition of micro-crystalline waxes. Small proportions of other materials such as polyisobutylene, polyethylene, resin and butyl rubber may be added. All the constituent materials must blend to give high electric strength, and the proportions are suitably chosen to give high softening points, and adequate plasticity over the operating temperature range. Compositions can include both natural and synthetic micro-crystalline waxes. Such waxes have fine crystal structures and the ability to hold or occlude oil, such characteristics being important for non-draining requirements. M.i.n.d. compounds retain a consistency somewhat like that of petrolatum, at temperatures up to about 85 deg. C. The melting points of the waxes used can vary over a wide range of about 70 to over 105 deg. C., and the viscosities of the oils too can vary from say about 5 to 1,000 centistokes at 60 deg. C.

OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

Super Refractory Fibres

Recent developments in the U.S.A. aircraft and missile field have shown a need for higher temperature resistant fibres for structural reinforcement, ablation materials and thermal insulation. H. I. Thompson Fibre Glass Co. have developed two types of ceramic fibres, zirconia and zircon, which meet these needs. The zirconia fibres can be supplied in either a high purity oxide, Zirconia A, or a pure multi-oxide composition, Zirconia B. Zircon is supplied in fine diameter wool form.

Zirconia A, (94 per cent $Zr\,O_2$ with 5 per cent stabiliser) consists of short fibres about $\frac{1}{4}$ in. long. and has a fairly high bulk density of approximately 21 lb./cu.ft. The fibre cross section is circular and between 0·0031 in. and 0·0005 in. diameter. Tests show that the tensile strength is somewhere between 85,000 and 100,000 p.s.i., but as these fibres had diameters slightly larger than current fibres, the tensile strength of the production fibres may be 200,000 p.s.i. or higher. While no test results have been obtained this fibre is believed to have a tensile modulus, possibly as high as 35×10^6 p.s.i.

Zirconia B (80 per cent $Zr\,O_2$) fibres are a combination of zirconia and other oxides, this combination resulting in a longer fibre in the woolly form which produces a bulk density of approximately 6 lb./cu.ft. The cross section is the same as that of the Zirconia A fibre, but Zirconia B fibres are much easier to handle and withstand more abuse during handling because of their longer length.

The Zircon fibres, (99 per cent $Zr\,O_2\,Si\,O_2$) appear to be those of the highest quality; they are very fluffy and recover well when the wool is compressed. From appearance and in handling, it appears that the flexural modulus of the zircon is lower than for either the Zirconia A or B fibre.

Stress Distribution in Lugs

It is reported that a systematic study by photo-elastic methods is being carried out at the Khar'kov (Russia) Polytechnic Institute to determine the relation between the stress distribution and the clearance in lug and pin connections. The tests have shown the extreme importance of the clearance in certain combinations of geometric parameters, and were made under static loading conditions with models of lugs made from a photo-elastic material; in plan form all the lugs tested were rings with attached rectangular shanks. Apart from the relative clearance between the pin and the lug, other variables were the relative width of the ring (ratio of the difference to the sum of the outside and inside radii), the relative width of the shank (ratio of shank width to pin diameter) and the relative fillet radius at the point of transition between the ring and the shank.

The quantitative evaluation of the stresses was made by the pattern of fringes obtained on the screen of the polariser installation when the model was traversed by monochromatic circularly polarised light. The results are stated as stress concentration factors (defined as the ratio of the actual maximum stress to the average stress when the lug is stressed in tension) as a function of the clearance for various values of the other parameters. It is shown that, when the relative width of the lug is small, the stress concentration factor at a relative clearance of 4 per cent can be two or even three times larger than at zero clearance. At a large clearance, the stress concentration factor reaches values exceeding 4.

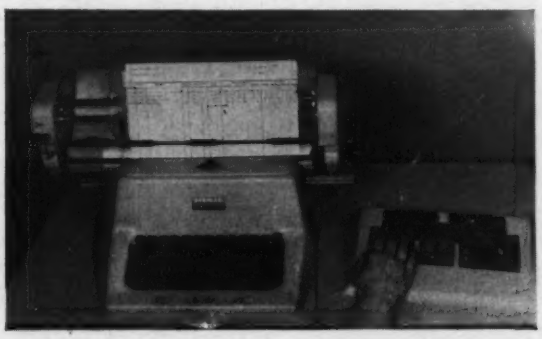
Scaffold Couplers

A cast steel scaffold coupler manufactured by P. Spreeuwenberg's Aanemingsbedrijf N.V., of Holland, enables a rectangular and rigid connection to be obtained between two steel scaffold tubes by means of two adaptable eccentric closures. The clamp is fixed to one of the tubes, and its design allows the second tube to rest on it. The second clamp may then be closed and tightened with a wrench in approximately half a turn, optionally to the left or to the right. There are no loose parts to get lost, and damaged or worn parts can be easily replaced.

Due to the relatively greater angular rigidity given by this connection as compared to the more conventional fittings generally employed, the permissible loads are higher, the ultimate advantage being that less scaffolding material is required. The eccentric clamp closure, which adapts itself to the tube tolerance, ensures a connection with a high sliding resistance. As the centre distance between two scaffold tubes becomes greater, the effective supporting power of the structure is reduced. With this new coupler the scaffold tubes are lying against each other, and consequently the eccentricity has the smallest possible value.

Electric Business Machines

The Eisenfelder works of Siemag, in Germany, have recently introduced a new series of triple entry book-keeping machines with full and abbreviated text systems; the models available are the Contaquick 5, 9 and 15, and the Multiquick 5. All these machines combine the control and programming ability of high-quality book-keeping machines with the arithmetical work of invoicing machinies. Special uses include technical discounting for manufacturers, complicated bank settlements and difficult invoicing problems. The multiplier unit of these four new Siemag models works electrically at very high speed.



EMD 7669 for further information

How zinc alloy die castings are helping manufacturers

This is the plated zinc alloy grille bar for the Austin A99 Westminster. Die casting was chosen to provide the rigidity needed to avoid distortion during polishing. The bar is 40 inches long, 0.080 - 0.100 inches thick and weighs $3\frac{1}{2}$ pounds. The fixing bosses are drilled and tapped because cored holes were ruled out by the different angles required. The plastic centre badge is mounted in a shallow cored recess.

How the Zinc Alloy Die Casters Association can help you

With technical data on properties and design. With booklets showing examples of varied applications. With advice on proposed die castings and finishes. By sending you a list of Member die casters. Write or telephone to: the Zinc Alloy Die Casters Association, 34 Berkeley Square, London, W.1. GROsvenor 6636

Sensitive Turbine Control

The French Atomic Energy Commission have recently developed a method by which the speed and power of high-speed reaction gas turbines may be regulated.

There are a number of instances where parts of equipment, such as the rotors of a neutron spectrometer, must be driven at very high speeds, and a turbine is an obvious answer, but the difficulty lies in the precise control of speed. A regulator governing the admission of the gas or fluid does not permit accurate and sensitive control.

In this French invention, the gas is admitted tangentially, a central distributor controlling the expansion by withdrawing part of the gas from the initial expansion and re-injecting it for a short period into blades positioned substantially diametrically opposite the zone of withdrawal. By suitable orientation of the central distributor, the power, and hence the speed of the turbine for a constant opposed couple, can be sensitively controlled.

A variation of this method consists of two coaxial rotors rotating in opposite directions and driven by a double expansion of the gas. This gas passes from the blades of the first rotor to the blades of the second, and then, via the

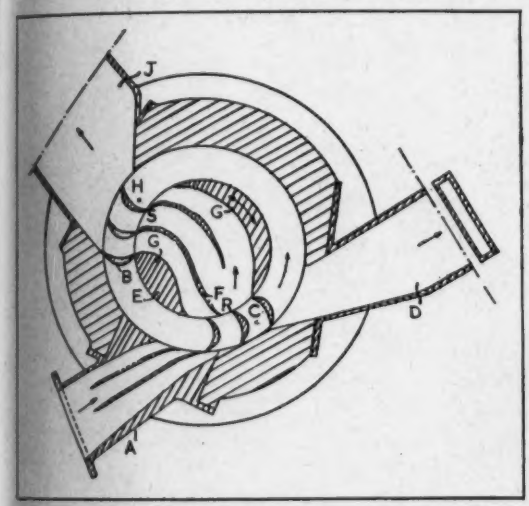


Fig. 1. Basic design for turbine control.

central distributor after expansion, back to the blades of the second rotor and then again to the first rotor before escaping.

In a third method, derived from the preceding one, the two coaxial rotors are separated by an annular distributor having blades of variable inclination, thus enabling the expansion in the second rotor to be controlled.

Fig. 1 shows how the propulsive gas is supplied, distributed and withdrawn. The gas is fed to the turbine by injection nozzle *A*, and during its first expansion acts on blades *R* in zone *C*. Part of the expanded gas escapes through exhaust main *D*, and part reaches the distributor *E*, and, by means of passages defined by partitions *F* between walls *G*, is fed to a second injection zone *H*. The gas expands a second time in acting on the blades *B* in zone *H*, and escapes through a main exhaust *J*.

Zone *H* is substantially diametrically opposite to zone *C*. The internal part of the distributor has approximately the shape shown in order to suppress turbulence and direct the gas streams tangentially from exit *S* in the direction of displacement of the blades. By rotating the distributor about its axis, which is also the turbine axis, it is possible to modify the amount of gas withdrawn after the first expansion, and consequently the operating characteristics. In the position

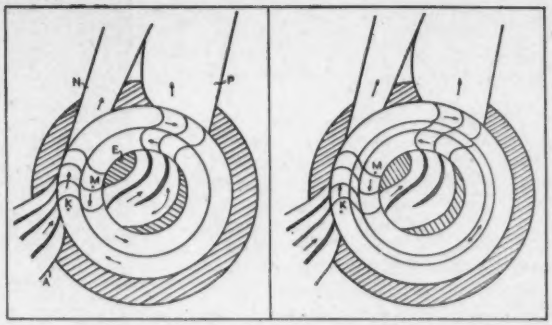


Fig. 2.

Fig. 3.

shown, double expansion of the gas is fully utilised and gives maximum power, i.e. maximum speed if the opposed couple is constant. By rotation through 90° from the position shown the distributor becomes inactive, and there is only a single expansion of the gas.

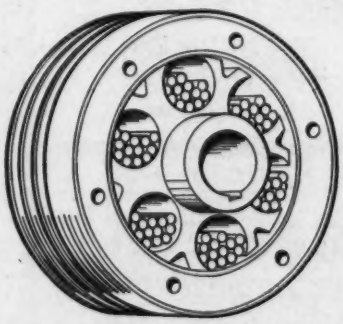
Fig. 2 shows a design having two rotors *K* and *M* rotating in opposite directions, which can be used in applications requiring two coaxial rotational movements in opposite directions and at different speeds. The gas, introduced by injection nozzle *A*, undergoes a first expansion in rotor *K*, a second expansion in rotor *M*, passes through distributor *E*, and then undergoes expansion twice more in rotors *M* and *K* respectively. Exhaustion of the gases takes place through a primary exhaust *N* and a secondary exhaust *P*.

Fig. 3 represents a variation of Fig. 2, an annular distributor being placed between rotors *K* and *M*. This distributor has a ring controlling the inclination of a series of directive blades distributed around its circumference. Manual or mechanical operation of the ring alters the inclination of the blades, and consequently the action of the rotor *M*. This enables the power or speed of rotor *M* to be regulated in relation to that of rotor *K*.

This control can be simply constructed, is very safe and flexible in operation, and enables very high speeds to be reached with stability.

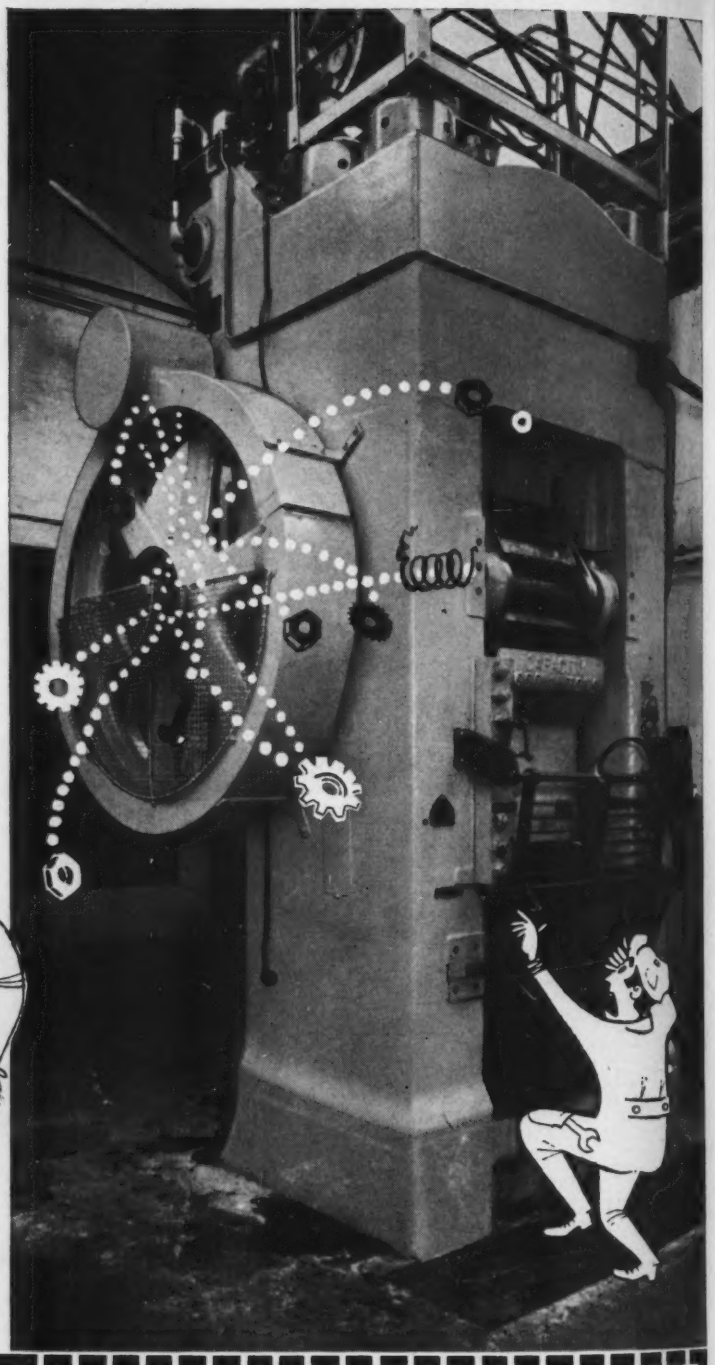
Centrifugal Clutch with Needle Elements

A German manufacturer, Hilger u Kern, has developed a patented form of centrifugal clutch with needle elements which is said to have a smaller bulk and a longer service life than similar centrifugal clutches. The hub, keyed on the driving shaft, has the form of a star and is set inside the plain bore of the pulley drum. Between the arms of



the star there are hollow lobes open at the periphery, partly filled with hardened steel needles. When the star rotates, the steel needles are thrown outwards by centrifugal force and pressed against the bore of the pulley drum. The nature of the centrifugal elements and the precise shaping of the lobes is believed to yield improved operation.

Joe's the boy for daydreams but when it comes to keeping up strict lubrication schedules he's likely to smash every dream of non-stop, top-capacity production! Happily nothing tempts Tecalemit Mechanical Lubrication Systems away from duty. Minute by minute *metered* shots of lubricant are fed to each and every bearing. Machines run more smoothly, have longer working life, give more reliable service. There are systems in the Tecalemit range to fit all machines and plant—new or existing—and to handle all lubricants—oil or grease. Get them to work for you and let Joe dream on, or, even better, find him a more productive job!



JOE ENJOYS A SMASHING DREAM

TECALEMIT

the Authority on Lubrication

TECALEMIT (ENGINEERING) LIMITED (SALES EMD)

PLYMOUTH · DEVON

To Tecalemit (Engineering) Limited (Sales EMD) · Plymouth · Devon

Please send me full information on:

SINGLE-LINE *Grease Injection System*—feeds each bearing through an independently regulated injector. ☐

RADIAL *Grease Pump System*—uses 19 miniature pumps to serve individual bearings. ☐

BRENTFORD *Automatic Multiline Oiling System*—has one to twenty-four lines, each with an independently regulated pump. ☐

BIJUR *Single-Line Oiling System*—one central pump serves up to 100 points, each with a pre-regulated metering valve. ☐

NAME _____

COMPANY _____

ADDRESS _____

_____

T744

New Books

Engineered Castings. *By Glenn J. Cook. (McGraw-Hill—66s.)*

The title of Mr. Cook's volume is rather ambiguous until the sub-title reveals the complete object—how to use, make, design and buy castings. The contents are laid out under these four phases of foundry work.

The first is covered by a rather general nineteen-page introduction to the applications and function of engineering castings. The second, and vital, phase is covered in sixty-five pages, from shell moulding to sand casting; each process is accurately, though briefly, explained in an admirable manner. Each method is discussed under the important headings of: Process, Application, Dimensional Accuracy and Cost. Thus each process can be quickly and accurately compared under these four vital features, to the satisfaction of an enquiry from other than a craftsman. One interesting feature of this section is the very well-illustrated method of making and pouring a sand casting; there are twenty-two actual photographs giving a very helpful sequence of operations. A set of review questions is given at the end of each chapter—this seems a rather futile exercise with such nondescript questions.

The "selection" phase is covered in an excellent manner, giving the vital information in the prime foundry metals—grey, malleable, ductile and nodular irons and steels. There is a very useful survey of vacuum-melted metals (details not normally found in the average text on this subject).

Good design is explained in a simple yet practical manner through the solidification of a casting. There is a comprehensive survey of actual design snags, and solutions are suggested—this would be very useful data for any design draftsman to read and digest. This is a practical survey with the cost factor under constant surveyance—compatible with function!

The final section of the work is on the buying of castings, patterns, etc. This aspect of the work is very rarely discussed in a technical book; hence this volume would be very useful for the background training of sales personnel and middle management to give them the necessary trade knowledge to perform their function.

R. H. Pritchard

Dynamic Analysis of Machines. *By Joseph E. Shigley (McGraw-Hill—58s.)*

This book is written as a companion to the author's *Kinematic Analysis of Mechanisms*, and can be obtained in combined form under the title *Theory of Machines*. After dealing with the fundamentals of inertia force and couple analysis in two- and three-dimensional mechanisms, the reader is introduced to the elements of vibration analysis. This is followed by chapters devoted to such specialised topics as engine dynamics, cam dynamics, and servo-mechanisms.

The author makes a feature of the use of unit vectors in force and moment analysis, which results in greater generalisation and some economy in working. Readers should be familiar with addition and multiplication of vectors and with the calculus as far as the solution of linear differential equations. Diagrams, which are used profusely throughout the book, are very clearly drawn and generally self-explanatory. The illustrative examples and problems presented for solution have been carefully chosen to bring out the principles and practical applications of the theory in each chapter.

The first chapter deals with static forces in mechanisms and gears, including the effects of sliding and turning friction. (The statement that "sliding friction is independent of the relative velocity" should surely be qualified as "aproximately true".) Then follows dynamic force analysis of plane and space mechanisms, the latter being concerned mainly with gyroscopic effects. It is perhaps unfortunate that the units of mass and moment of inertia are not more clearly defined, as there is some inconsistency between page 389 where I is quoted in lb. sec.^{2} in. and m in lb. sec.^{2}/ft., and page 393 where it is stated that "$I=mk^2$".

The section on vibration analysis makes use of vector representation of differential equations and phase-plane plots to analyse transient motions. Damping and vibration isolation are discussed, and approximate numerical methods are given for the solution of transverse and torsional vibrations.

The chapter on balancing of rotating masses, in addition to the conventional methods of analysis, gives a good discussion of the operation of the various types of balancing machine available. It is surprising, however, in dealing with engine dynamics, that the graphical method for balancing of reciprocating parts is not employed. A chapter on cam dynamics follows, in which the forces and torques developed are applied to follower systems, making allowances for mass and flexibility. Thus cam motion and follower response are compared, and phenomena such as jump, shock and spring surge are discussed.

In the final chapter an introduction to feedback control systems is given. Proportional error linear systems are dealt with, and response, stability and steady-state error are analysed.

Within the limitations of about 300 pages this book gives a sound treatment of engineering dynamics, and should appeal alike to students and practising engineers.

G. H. Ryder

Spectra and Analysis. *By A. A. Kharkevich. (Consultants Bureau Enterprises Inc.—$8.75.)*

Both the Russians and the Americans are busily translating each other's texts, and this book is an American translation of the third edition of the Russian book. The translation is in general good, but is marred in places by unhappy translation.

The book is chiefly concerned with problems in Fourier analysis, and is addressed to the engineer with the main purpose of discounting misplaced criticisms of, and false conclusions drawn from, this method of analysis.

There are only three chapters in the book, but seven appendices are devoted to the more difficult mathematical problems. In these three chapters the spectral representation of time varying physical quantities, the experimental methods of measuring such spectra, and the spectral theory of random processes are discussed.

The first chapter is mostly a conventional exposition of Fourier series and Fourier transforms from an engineering outlook. In this chapter spectra of various types of signals of interest to the electrical engineer are fully discussed, together with the relationship between the input and output spectrum of a physical device. One novelty is the discussion of running and instantaneous spectra; these concepts, although well known, are not often discussed in Western text books.

The second chapter discusses physical methods of measuring spectra. Numerical methods are excluded, and all measurable physical quantities are, for simplicity, considered to be converted to electrical quantities. This chapter is well written, and fully discusses the use of resonators (or filters) and electrical methods of obtaining Fourier transforms directly.

The third chapter discusses the more modern aspects of the subject, such as the spectra of random processes. Altogether some fifty pages divided into six sections are devoted to this subject. The first section discusses the spectral representation of random processes and introduces power spectra, correlation functions and the relationship between these quantities. The treatment is conventional and somewhat condensed. As an example, the spectrum of the output of a two state system with transitions between the states occurring randomly in time is analysed. This depends upon the distribution function of the times at which transitions occur.

Twenty pages are devoted to the more difficult subject of non-stationary processes, but the treatment is cursory and the examples treated can equally be regarded as stationary by introducing simple artifices. There is a section on the properties of finite samples of stationary random processes mostly devoted to energy distribution in the samples, and the treatment is based on Rice.

The last section deals with the consideration of narrowing the spectrum of a signal without loss of information, and is closely related to the problem of optimal coding. However, this section is far too short to give anything but a glimpse of the subject.

In general the older types of problem are well discussed in this book, but the more modern aspects of the subject are less adequately covered.

Dr. R. A. M. Bound

EMD 7671 for further information

HOLLOW STRUCTURAL STEELWORK

In this aggregate conveyor, built by Penfolds (Builders' Merchants) Ltd., for their ready-mixed concrete plant, Rectangular Hollow Sections were used.

A wide range of sizes is available: square from 1″ to 5″, and rectangular from $1\frac{7}{8}$″ x $\frac{1}{2}$″ to 6″ x 4″, all conforming to the material specification of BS 1775, Grade 16.

Our technical representatives will gladly give advice where projects incorporating hollow structural steelwork are involved.

A pamphlet giving full dimensions, properties and prices will be sent on application to Stewarts and Lloyds Limited, Structural Steel Department, Broad Street Chambers, Birmingham 1. Telephone: Midland 2700. Telex 33333.

The drawing shows one of the welded connections on the lattice structure.

PRODUCT OF S&L

New Books (cont. from page 683)

Applied Theory of Gyroscopes. *By B. V. Bulgakov.* (*Israel Programme for Scientific Translations*—$3.)

Although the specialist will not find anything new in this book, the contents are fairly comprehensive considering the date of the original work. As an introduction to gyroscopic theory for those mathematically minded it is well collated with examples of historic applications. The author died in 1952, and the book is a second edition of that which he first published in 1939; an attempt has been made to modernise it by including a collection of later papers and works by the author.

As an example of a translation of a scientific work it is as near perfect as one could wish for, and Jacques J. Schorr-Kon is to be complimented upon his treatment. It is unfortunate that the printing and illustrations and photo reproductions are poor compared with American and British equivalents. For the practical engineer the most important contribution in the book is a very short reference to the principle of power-gyro stabilisation. This refers to a paper which was first published in 1948 in the proceedings of the National Academy of Sciences, U.S.S.R. Chronologically, this is the most modern reference in the book. It deals with the modern method of employing power follow up by measuring precessional deviation as a signal and then applying correcting torques in quadrature.

In the last ten or twelve years much advance has been made in the field of integrating gyroscopes, which has made possible inertia navigation for use in submarines and inter-continental and space flight. For the reader to gain a more complete picture of what has been achieved he would be well advised to read this book in conjunction with those that have been written by Dr. Draper and his colleagues at Massachusetts Institute of Technology on his flotation gyro, which is the greatest advance in gyro navigation and stabilisation in recent years.

John Tindale

Value Engineering, Vol. 2. *Edited by Richard S. Mandelkorn.* (*Reinhold; Chapman & Hall*—67*s.*)

Way back in the 1890s Prof. Cawthorne Unwin gave a very concise definition of machine design which included "On the drawing the engineer . . . considers all the modifications which tend to greater efficiency of working or less cost of manufacture". This is an early recognition of "the fact that engineering consists of two entirely different bodies of knowledge—first, how hardware behaves; and second, how and what hardware can be made" as D. L. Marples has recently put it.

Value engineering results really through finally making a break between these two aspects of design. In the U.S.A., engineers, designers and draftsmen are all college trained, and those in closest contact with the hardware design have not the same background as those in Britain trained through industrial apprenticeships. These circumstances have resulted in American industrial pioneering Value Engineering (VE) through sheer necessity. However, there are other circumstances which have helped VE to grow in the U.S.A. which will probably lead in time to its increase in Britain.

Today there are so many parts which can often be bought out, and as technology progresses there are an increasing number of ways of manufacturing parts and an increasing variety of materials which can be used. Designers, particularly those with a predominantly functional training, cannot help but become less and less knowledgeable of the cost of their designs. VE is not, however, just a buying or production function. It does not start with a part as defined by the designer, it ascertains what the designer requires functionally and helps to state or restate the specification in beter terms as regards overall value, and it is, therefore, part of the design function.

Whilst VE has no firm limits its main application is in the field of quantity production—a better criterion than size of organization—as a VE programme itself costs money which has to be covered before savings appear. Initially VE was applied to work already in production when the costs of individual parts could be examined in relation to functional importance. Over the years experience has been gained, and many VE teams now get on the job while a design is in its early stages. What has been done to date has been voiced in America through two conferences organised by the Electronic Industries Association. The first group of papers was published under the title of *Value Engineering* 1959; the present volume covers the second conference.

Unlike most earlier publications on value analysis, this book contains very few detailed examples which might be of direct value to designers—what examples are given do show spectacular savings, although many British designers might consider these to be just cashing in on poor original design. The book is concerned far more with: the general philosophy of VE; the kind of VE organisations which can be used in various companies; how to build up a VE staff; training for those actively engaged on VE; and selling VE throughout a firm. In other words this collection of papers is predominantly aimed at management, and rightly so as such programmes have to be initiated from the top. The contents are not restricted to the electronic industry; the coverage is much wider and, indeed, four papers are respectively devoted to the VE programmes of the Department of Defense, the Army, the Navy and the Air Force.

While there are value analysis departments in some of the larger British organisations, it is doubtful whether very much of our industry is yet at a stage where VE as such is necessary or desirable, but it is probably only a question of time, and forward-looking management would do well to keep in touch with American experience.

P. J. Booker

Engineering Data for Product Design. *Edited by Douglas C. Greenwood* (*McGraw-Hill*—77*s.* 6*d.*)

Many readers will undoubtedly be familiar with the various reference sheets published over the years in *Product Engineering*, and the many short articles presenting factual or tabulated information. A lot of these have been reprinted, and there has apparently been a continual demand long after copies were exhausted. As a result Mr. Greenwood, who edits *Product Engineering Design Digest*, has collected together about 160 selected articles and data sheets in over 400 pages to form this book.

The main sections are headed: General Engineering; Metals and Alloys; Nonmetallic Materials and Finishes; Components and General Design Analysis; Beams; Torque and Moment of Inertia; Bearings and Shafts; Gears; Springs and Vibrations; Mechanical Control; Fastening and Joining; Electricity and Electronics; and Hydraulics and Pneumatics.

A lot of thought has obviously gone into the selection of material, its editing and grouping. Although a comprehensive index is provided, the arrangement is such that most information can be pin-pointed simply by looking under the appropriate sub-heading in the contents list.

A book of this nature is in many ways short of the ideal. There is not the same cohesion in the contents that one finds in a book deliberately written from scratch for a purpose, and much fairly standard data could usefully be interpolated for comprehensiveness. On the other hand it has peculiar advantages. The work does not become a sort of text book; neither does it become merely a reference book, like a dictionary, which one consults only when necessary. It is rather closer to an encyclopedia of not generally accessible data—a reference work in which each item is complete in itself and which can be browsed through with enjoyment. Since the information contained in this book is not on the whole the standard material found in books, continual browsing through is probably the best way to use it.

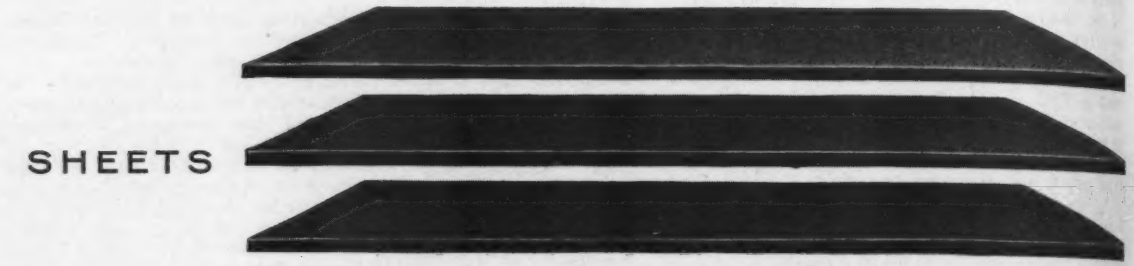
As with all books from the U.S.A., the use of abbreviations for standards not familiar to British readers—such as "standard AGMA proportions"—is a little disconcerting. In many cases these references do not detract from the value of the information given because they are equivalent to British Standards, but they make one hesitate to accept it without question.

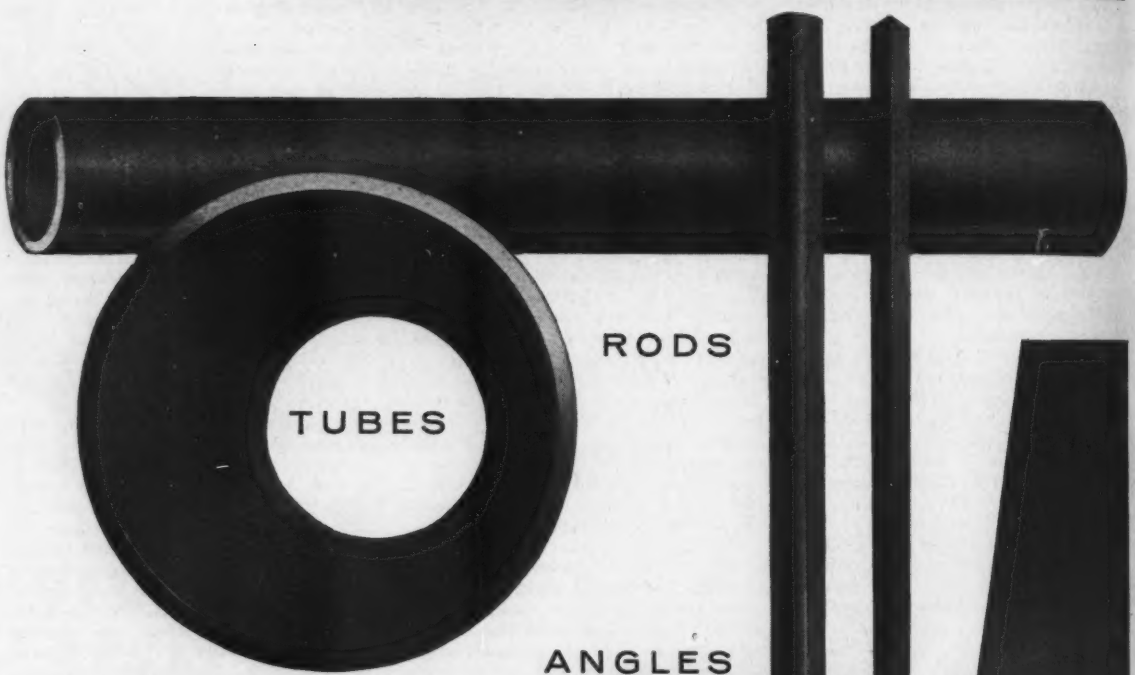
On the whole the book is a useful and interesting collection of design material, more appropriate, perhaps, for the general product designer than the specialist.

P. J. Booker

EMD 7672 for further information

TUFNOL





Tufnol—the tough, versatile material of today—is made in sheets, tubes and rods that can be machined easily and accurately with ordinary engineering tools. It is available in several brands to suit particular requirements, and has thousands of different uses ranging from ships' bearings to moulded railtrack insulators. Supplied to meet appropriate British Standards and Government Specifications.

Available in sheets, tubes, rods, angles, and channels and in several brands.

Keep up-to-date
visit Stand C10
ENGINEERING MATERIALS AND DESIGN EXHIBITION
Earls Court
November 13—18

STRONG BUT LIGHT
RESISTS CORROSION
ELECTRICAL INSULATOR
MACHINES EASILY
STORES INDEFINITELY

TUFNOL LIMITED · PERRY BARR · BIRMINGHAM 22B

387

COBALT-BASE SUPER-ALLOYS

Engineering Materials and Design
DATA SHEET No. 68

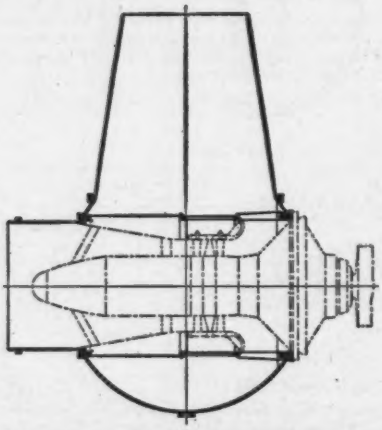
New cobalt-base alloys are finding ready application where working temperatures are in the range 920 to 1,100 deg. C. The following data applies to some of the newer super-alloys which are available in the U.K. The tabulated values shown below are only typical, and should not be used at face value for comparison between the materials. For further details, reference should be made to the company concerned. Other cobalt-base alloys have been tested by the Battelle Memorial Institute and also by the Centre d'Information du Cobalt, of Brussels.

Alloy	Other Main Constituents (%)	Average Stress for Rupture (p.s.i.)				Typical Short-time Data							
						U.T.S.				0·2% Offset Yield			
		10 hr.	100 hr.	1,000 hr.	Temp. (°C.)	R.T.	540°C.	820°C.	980°C.	R.T.	540°C.	730°C.	870°C.
Wrought Alloys Haynes Alloy No. 25 (supplied by Samuel Osborn & Co. Ltd.)	9·0—11·0 Ni 19·0—21·0 Cr 14·0—16·0 W												
Sheet (heat-treated at 1,230°C.)		30,000	22,000	17,500	820	145,900	115,700	(870°C.) 46,600	34,400	67,200	35,800	—	34,500
		5,600	2,800	—	1,100								
Bar (heat-treated at 1,230°C.)		30,000	22,000	17,000	820	150,000	109,000	65,700	32,900	70,000	—	—	—
		6,000	3,300	1,800	1,100								
										0·1% Proof Stress (p.s.i.)			
		30 hr.	100 hr.	1,000 hr.		R.T.	500°C.	800°C.	900°C.	R.T.	500°C.	800°C.	900°C.
Jessop G-32 Alloy (supplied by Jessop-Saville Ltd.)	12·0 Ni 19·0 Cr 1·2 Nb 2·0 Mo 2·8 V												
Heat-treated at 1,280 °C., followed by aging at 75°C.		44,800	40,320	33,600	750	147,840	116,480	86,240	47,040	109,800	79,520	59,360	32,480
		28,000	22,848	15,000	850								
		67,200	4,480	14,560	1,000					0.2% Offset Yield (p.s.i.)			
		10 hr.	100 hr.	1,000 hr.	Temp. (°C.)	R.T.	540°C.	820°C.	980°C.	R.T.	540°C.	730°C.	870°C.
Casting alloys Haynes Alloy No. 31* Stellite X-40†	9·5—11·5 Ni 24·5—26·5 Cr 7·0—8·0 W												
As cast		61,000	56,000	51,000	650	108,000	80,000	63,200	29,400	76,200	40,600	37,800	—
		33,000	27,000	22,000	820								
		13,000	11,000	9,800	980								
Aged 50 hr. at 730°C.		—	28,700	23,200	820	128,300	—	59,600	—	112,700	(820°C) 44,500	—	36,200
		6,300	4,000	—	1,100								
Haynes Alloy No. 21* Stellite 8†	1·75—3·75 Ni 25·5 —29·0 Cr 5·0 —6·0 Mo												
As cast		70,000	52,000	42,000	650	101,300	73,500	62,500	32,000	82,300	39,300	39,100	—
		27,500	19,000	13,500	820								
		12,500	9,400	7,00	980								
Aged 50 hr. at 820°C.		—	22,000	14,200	820								
		—	17,100	13,400	870								
Aged 50 hr. at 730°C.		4,200	—	—	1,100	124,500	94,000	59,000	(870°C) 41,600	110,400	80,200	61,200	32,900
		30 hr.	100 hr.	1,000 hr.						0·1% Proof Stress (p.s.i.)			
Jessop-Saville G.65 (supplied by Jessop-Saville Ltd.)	10·5 Ni 25·5 Cr 7·5 W	64,960	43,680	33,600	750	106,176	(650°C.) 82,208	—	—		(650°C)		
		34,720	30,240	23,968	815					59,584	57,568	—	—
		9,184	7,168	4,704	1,050								
Jessop G.34 (supplied by Jessop-) Saville Ltd.)	12·0 Ni 19·0 Cr 17·0 Fe	42,560	38,080	30,240	750	89,600	—	—	—	58,240	—	—	—
		23,520	20,160	16,352	850								
		7,840	6,496	3,584	1,000								

* *Supplied by Samuel Osborn & Co. Ltd.* † *Supplied by Deloro Stellite Ltd.*

EMD 7673 for further information

New thinking for Trawsfynydd

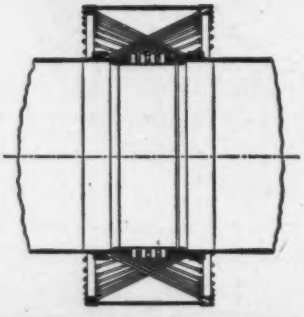


CO_2 CIRCULATORS

As every engineer knows, the thickness of plate required to contain a given pressure is halved if the vessel is spherical instead of cylindrical. It is odd—but nevertheless true—that it was not until our own engineers were confronted with the design of the CO_2 circulatory system for Trawsfynydd that the elementary principle was put into practice on large pressure pipework.
Besides halving the plate thickness spherical construction has other advantages. All welds are circular, can be prepared by machinery and are simple to X-ray.

CORNER BENDS

The same advantages follow when the same principle is applied to corner bends. In addition, the stiffeners required on cylindrical bends are eliminated. Internal tubes—not subject to pressure—provide a smooth gas flow.



EXPANSION JOINTS

It is standard practice to take up the expansion of large diameter pipework by flexing at what are essentially hinged joints. These of course have to provide restraint against axial forces—over 1,000,000 lb. in the Trawsfynydd ducting. The usual solutions, an internal metal tongue or a hinged joint are heavy, cumbersome and, moreover, flexible in one direction only. The hinge we have devised is flexible in *all* directions, by elastic straining of the high-tensile steel, restraining rods. The circumferential pressure is taken by a metal bellows, faired internally by a floating sleeve.

These ideas are not our only contribution to Trawsfynydd. As well as the complete CO_2 circulation system, we are building the whole of the generating plant, comprising steam turbo-alternators, condensing plant and feed heating systems.

RICHARDSONS, WESTGARTH & CO LTD

The Controlling Company of the RICHARDSONS WESTGARTH GROUP, Wallsend, Northumberland, and 58 Victoria Street, London, S.W.1

ASSOCIATED COMPANY: ATOMIC POWER CONSTRUCTIONS LTD.

RW 74

HIGH ALLOY STEELS, Ni AND Co ALLOYS FOR INVESTMENT CASTINGS

Engineering Materials and Design
DATA SHEET No. 69

BS 3100 covers all existing British Standards for steel castings made by conventional sand foundries for general engineering purposes. These proved unsuitable for the specialised requirements of investment foundries and in 1959, BS 3146, Part 1 (covering carbon and low alloy steels) was issued. *E. M. & D.* Data Sheet No. 51 (December 1960) summarised Part 1 of this specification.

BS 3146, Part 2 has now been issued covering high alloy steels, nickel and cobalt alloys. This specifies many alloys not previously

Summary of Steels in BS 3146, Part 2: 1961

			Chemical Composition % (Maximum, unless otherwise stated)															
Specn.	Grade	Type of Steel	C	Si	Mn	Ni	Cr	Mo	Cu	Ti	Co	Fe	W	Nb	Al	Mg	S	P
ANC 1	A	13% Cr	0·15	1·25	1·00	1·00	11·50-13·50	0·15	0·40	—	—	—	—	—	—	—	0·050	0·050
	B		0·12-0·20	1·25	1·00	1·00	11·50-13·50	0·15	0·40	—	—	—	—	—	—	—	0·050	0·050
	C		0·20-0·30	1·25	1·00	1·00	11·50-13·50	0·15	0·40	—	—	—	—	—	—	—	0·050	0·050
ANC 2		18% Cr	0·25 —	0·10-1·0	1·0 —	1·0-3·0	15·5-20·0	—	—	—	—	—	—	—	—	—	0·045	0·045
ANC 3	A	Austenitic Cr/Ni	0·12	2·00	2·00	7·5 (min.)	17·0 (min.)	—	—	—	—	—	—	—	—	—	0·045	0·045
	B	(Nb)	0·12	2·00	2·00	8·5 (min.)	17·0-20·0	—	—	—	—	—	—	8xC 1·10	—	—	0·045	0·045
ANC 4	A	Austenitic Cr/Ni/Mo	0·08	1·50	2·00	11·0-14·0	18·0-20·0	3·00-4·00	—	—	—	—	—	—	—	—	0·045 —	0·045 —
	B		0·08	1·50	2·00	10·0	16·5-18·5	2·00-3·00	—	—	—	—	—	—	—	—	0·045 —	0·045 —
	C	(Nb)	0·12	1·50	2·00	10·0	16·5-18·5	2·25-2·75	—	—	—	—	—	8xC 1·10	—	—	0·045	0·045
ANC 5	A	Ni/Cr	0·5	3·0	2·0	17·0-22·0	22·0-27·0	—	—	—	—	—	—	—	—	—	—	—
	B		0·5	3·0	2·0	36·0-46·0	15·0-25·0	—	—	—	—	—	—	—	—	—	—	—
	C		0·75	3·0	2·0	55·0-65·0	10·0-20·0	—	—	—	—	—	—	—	—	—	—	—
ANC 6	A	Cr/Ni castings	0·15-0·30	0·75-2·0	1·0	10·0-15·0	20·0-25·0	—	—	—	—	—	—	—	—	—	0·045	0·045
	B		0·15-0·30	0·75-2·0	1·0	10·0-15·0	20·0-25·0	—	—	—	—	—	2.5-3·5	—	—	—	0·045	0·045
ANC 7		Cr/Ni/Co castings	0·30-0·40	0·60-1·60	0·5-1·0	12·0-14·0	18·0-20·0	1·5-2·0	—	—	9·0-11·0	—	2·0-3·0	2·5-3·5	—	—	0·045	0·045
ANC 8		Ni/Cr castings	0·05-0·15	0·20-1·0	0·20-1·0	rem.	18·0-22·0	—	—	0·2-0·6	—	5·0	—	—	0·4-1·0	—	—	—
ANC 9		Ni/Cr/Ti castings	0·03-0·10	0·20-0·1	0·20-1·0	rem.	18·0-22·0	—	—	2·20-3·00	—	5·0	—	—	0·8-1·16	—	—	—
ANC 10		Ni/Cr/Co/Ti castings	0·05-0·12	0·20-1·0	0·20-1·0	rem.	18·0-22·0	—	—	2·20-3·00	15·0-20·0	5·0	—	—	0·8-1·16	—	—	—
ANC 11		Ni/Cr/Co/Mo castings	0·27-0·40	0·2-0·5	0·2-0·5	rem.	18·0-23·0	9·5-11·0	—	0·30	9·0-11·0	1·0	—	—	0·20	—	—	—
ANC 12		Ni/Cr/Mo/Ti castings	0·10	1·00	1·00	rem.	20·0-23·0	9·0-10·5	—	2·2-2·8	1·0	1·0	—	—	0·5-0·9	—	—	—
ANC 13		Co/Cr/Ni/W castings	0·45-0·60	1·5	1·5	9·5-11·5	24·0-27·0	—	—	—	rem.	2·0	6·5-8·5	—	—	—	—	3
ANC 14		Co/Cr/Mo castings	0·2-0·3	1·0	1·0	1·75-3·75	25·0-29·0	5·0-6·0	—	—	rem.	3·0	—	—	—	—	—	—
ANC 15		Ni/Mo castings	0·02-0·12	0·5-1·2	0·5-1·2	rem.	—	26·0-30·0	—	—	—	4·0-7·0	—	—	—	—	0·030	—
ANC 16		Ni/Mo/Cr castings	0·05-0·15	0·5-1·2	0·5-1·2	rem.	15·5-17·5	16·0-18·0	—	—	—	4·0-7·0	3·75-5·25	—	—	—	0·030	—
ANC 17		Ni/Si castings	0·05-0·12	8·5-10·0	0·5-1·2	rem.	—	—	2·0-4·0	—	—	2·0	—	—	—	—	0·030	—
ANC 18	A	Ni/Cu/Si castings	0·1-0·3	0·5-1·5	0·5-1·5	rem.	—	—	28·0-32·0	—	—	3·0	—	—	—	0·07-0·13	0·050	—
	B		0·05-0·15	2·5-3·0	0·5-1·5	rem.	—	—	28·0-32·0	—	—	3·0	—	—	—	0·07-0·13	0·050	—
	C		0·05-0·15	3·5-4·5	0·5-1·5	rem.	—	—	28·0-32·0	—	—	3·0	—	—	—	0·05-0·13	0·050	—

†Registered trade mark, Henry Wiggin Ltd. ‡Proprietary alloy, Rolls Royce. *Registered trade mark, William Jessop. §Registered trade mark, Deloro Stellite

covered by a British Standards casting specification. The alloys covered include the corrosion resistant 13% and 18% chromium steels, as well as the austenitic heat- and creep-resistant stainless steels. The higher duty cobalt- and nickel-base alloys, which have a special resistance to high-temperature creep and oxidation as well as to particularly corrosive conditions, are also covered. The advantages of investment castings produced from the alloys described in the Standard are the complexity of shapes that can be cast, together with the good surface finish and close dimensional tolerances to which the castings can be produced. The Table also shows the comparable British Standard specification, or where no such specification exists, the trade name of the alloy.

Data by courtesy of The British Investment Casters' Technical Association.

Mechanical Properties

U.T.S. (min.) (t.s.i.)	Yield Stress (min.) (t.s.i.)	Elongation (min.) (%)	Comparable Specn: Castings and Wrought	Remarks
35	24	20	BS 1630 A EN 56 A	Corrosion- and rust-resisting steel possessing medium tensile strength.
40	29	18	BS 1630 B EN 56 B	Hardness (HB): A, 152–207; B, 183–229; C, 201–255. (H. & T.)
45	30	15	BS 1630 C EN 56 C	
55	45	10	EN 57	Better corrosion- and rust-resisting steel than ANC 1, with higher u.t.s. H. & T.
30	13·5	25	BS 3161 A EN 58 A	Corrosion- and acid-resisting stainless steel with moderate tensile strength. When castings are to be welded without subsequent heat-treatment use ANC 3B. (S.T.).
30	13·5	25	BS 1631 B Nb EN 58 F	
30	13·5	15	BS 1632 A En 58 J	Corrosion- and acid-resisting stainless steel better than ANC 3; possesses moderate tensile strength. The stabilised grade ANC 3 C Nb is recommended when castings are to be welded without subsequent heat-treatment. (S.T.).
30	13·5	15	BS 1632 B EN 58 H	
30	13·5	15	BS 1632 C Nb EN 58 H	
—	—	—	BS 1648 F	Heat-resistant alloys with a marked resistance to scaling at elevated temperatures up to 1,050°C. (A.C. or S.T.).
—	—	—	BS 1648 H	
—	—	—	BS 1648 K	
30	—	20	BS 1648 E	Heat-resistant alloys with a marked resistance to scaling at elevatedtemperatures. Useful creep strength up to 650°C. Hardness (HB): A and B, 250 max. (A.C.).
30	—	20	BS 1648 E EN 55	
35	20	—	G 19* G 19*	Heat-resistant alloy possessing useful creep strength up to 750°C. (A.C.).
27	—	5	Nimocast 75* Nimonic 75†	Heat-resistant alloy with good resistance to oxidation; readily welded. (A.C.).
37	27	5	Nimocast 80† Nimonic 80†	Good resistance to oxidation, and good creep strength up to 750°C. (S.T. & Aged).
37	27	5	Nimocast 90† Nimonic 90†	Heat-resistant alloy. Good thermal shock resistance up to 1,100°C. (S.T. & Aged).
27	—	5	Nimocast 242† C 242‡	Heat-resistant alloy. Good thermal shock resistance up to 1,100°C. (A.C.).
33	—	5	C 130‡	Heat-resistant alloy with useful creep strength and good thermal shock properties. (A.C.).
42	27	5	X 40§	Heat-resistant alloy. Useful creep strength and good thermal shock properties (A.C.).
40	28	5	Stellite 8§	Good thermal shock properties, and also good wear resistance. (A.C.).
30	15	10	Hastelloy B	Corrosion and heat-resistant alloy. Useful creep strength up to 800°C. (A.C.).
28	15	5	Hastelloy C	Corrosion and heat-resistant alloy. Useful creep strength up to 800°C. (A.C.).
20	—	—	Hastelloy D	Acid- and corrosion-resistant alloy. (A.C.).
20	7·5	15	Monel† Monel†	Acid- and corrosion-resistant alloys suitable for use where resistance to mineral acid and salt water corrosion is required. (A.C.).
28			Monel H†	
38			Monel S†	

Conditions for testing: H. & T.=Hardened and tempered; S.T.=Solution treated; A.C.=As cast.

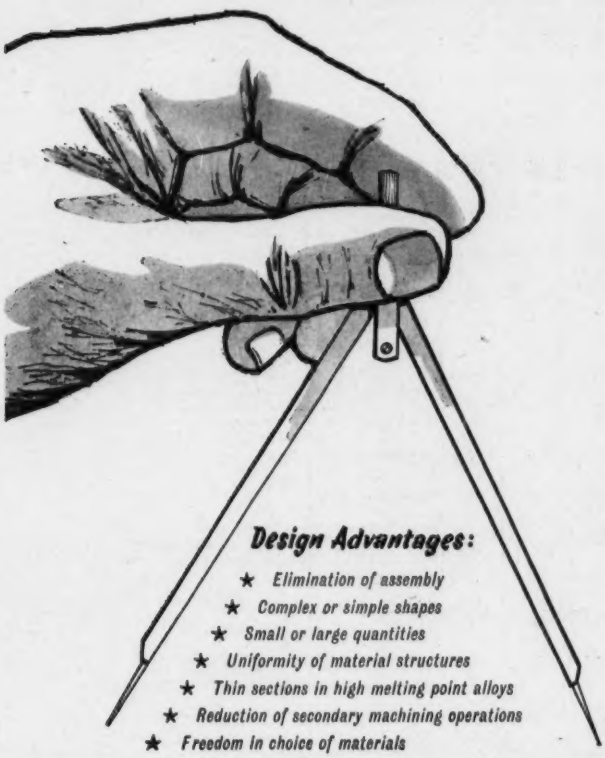
EMD 7674 for further information

A greater measure of freedom

for DESIGNERS...with

PICASTINGS

INVESTMENT CASTINGS
PRODUCED BY PICAST CENTRIFUGAL PROCESS



Design Advantages:

- ★ *Elimination of assembly*
- ★ *Complex or simple shapes*
- ★ *Small or large quantities*
- ★ *Uniformity of material structures*
- ★ *Thin sections in high melting point alloys*
- ★ *Reduction of secondary machining operations*
- ★ *Freedom in choice of materials*

For full details
write for
Leaflet P.I.2

P.I. CASTINGS (ALTRINCHAM) LTD
ATLANTIC STREET · ALTRINCHAM · CHESHIRE
Telephone: Altrincham 2702 (5 lines) Grams: Precisely Altrincham
Telex 66-105-A/B Atlantic Altchm

P.I.8

REVIEW OF DESIGN COURSES

The following courses relevant to the theory and practice of engineering design have been announced for the 1961-62 session

Essex

Braintree College of Further Education, Church Lane, Braintree. "Industrial Design Course", six to eight hours a week covering all relevant subjects from Aesthetics and Colour to Model-making. The course is intended as a comprehensive introduction to design, and no award is given. An endorsement of a major exam. is envisaged. There is also a "Basic Course" for students wishing to enter industry with some knowledge of the design of industrial and engineering products. Some students may continue their studies and take the N.D.D. in Industrial Design.

Hertfordshire

Hatfield Technical College, Hatfield. "Metal Forming Technology", in which lectures will be given by specialists or consultants in industry and research on the techniques of forming sheet bar and metal powder into useful shapes. Other shaping methods such as casting, extrusion and die stamping will also be considered; eight evening lectures, commencing October 11. In addition, there will be a short course on "Fluid Power Control", covering the theoretical design and industrial application of fluid power to control engineering, and embracing such subject matter as Automatic Control, Fluid Dynamics, Theory of Machines, and Mathematics and Instrumentation; 9 a.m. to 5 p.m. from October 30 to November 17.

Lancashire

City of Liverpool College of Technology, Byrom Street, Liverpool 3. A one-year full-time course in "Engineering Design and Stress Analysis", for students who have obtained a good Higher National Certificate in Mechanical Engineering but still require endorsement subjects on their O.N.C. or H.N.C. to satisfy the requirements of the Institution of Mechanical Engineers for complete exemption from the Associate Membership examination. In addition, regulated instruction in the subject of Design and Stress Analysis will occupy over one-third of the time throughout the course.

Salford Technical College, Peel Park, Salford 5. "Industrial Design", a full-time course of four to five years which leads to professional qualifications in both art and engineering, and includes science, commerce and marketing. The course also incorporates a period of full-time industrial experience in an engineering firm.

Two part-time courses are also available: "Basic Industrial Design Course", extending over a period of 25 weeks (62½ hr.), and divided equally into Theory and Practical; "Advanced Industrial Design Course", approximately 62½ hr. over 25 weeks in one session, covering Theory and Practical, Industrial Design and Ergonomics.

London

Council of Industrial Design, The Design Centre, 28 Haymarket, S.W.1. Two design appreciation courses for engineers. Both will take place in the London area, and both will be residential. The "Staff Course" is intended to impart an appreciation of industrial design to draughtsmen and associated staff, and to apprentices completing their training. The "Executives' Course", specially prepared for engineering management, aims at showing the developing importance of industrial design aspects in engineering, imparting an appreciation of design in its widest context, and describing ways of making design improvements.

The Institute of Welding, 54 Princes Gate, S.W.7. Evening courses in "Design for Welding in Steel Construction", to be held in Birmingham (November 1961 to February 1962), Leeds (January 1962 to April 1962), and Bristol (January 1962 to April 1962). "Detail Design of Welded Structural Steelwork" evening course will be in Manchester (November 1961 to February 1962).

The following day courses are to be held in London: "Welded Pressure Vessels" (October 2 to 6, 1961); "Design for Welding in General Engineering" (December 4 to 8, 1961), and "Design of Welded Pipework" (January 29 to 30, 1962).

Willesden Technical College, Denzil Road, Willesden, N.W.10. "Design with Non-metallic Materials", six meetings beginning January 17, 1962 (7 to 9 p.m.), intended for graduates, holders of a National Certificate or Diploma, or practising instrument engineers. Subjects dealt with will include the Manufacture and Properties of Plastics Materials.

Nottinghamshire

Nottingham & District Technical College, Burton Street, Nottingham. Higher National Certificate Endorsement course in "Mechanical Engineering Design", Tuesday and Friday evenings for the whole session. The examination will consist of two papers, the first a written paper on design principles, and the second consisting of a specific design.

In addition, a post-graduate course of twelve lectures on "Pumps and Compressors" will be held on Monday evenings from 6.45 to 9 p.m., commencing September 25, 1961. The responsible lecturer will be assisted by specialist lecturers from industry. The course will deal with the practical design of reciprocating centrifugal, and particularly, axial flow pumps and compressors, and is intended for persons having an engineering degree, or holding an H.N.C. in mechanical engineering.

Warwickshire

Lanchester College of Technology, Priory Street, Coventry. A one-day course in the department of production engineering, entitled "Toxic Materials and the Production Engineer", to be held on February 28, 1962.

Yorkshire

Bradford Institute of Technology, Bradford 7. Specialist lectures on Tuesday evenings from 7 to 9 p.m.: October 3, 1961, "Industrial Design"; October 10, "Ergonomics in Design"; October 17, "Design for Reliability"; October 24, "Standards in Design"; October 31, "Design for Safety"; November 7, "The Process of Engineering Design".

Constantine Technical College, Middlesbrough. A short course on "Engineering Design" is to take place in 1962, covering all aspects of design from costs and economics to aesthetic considerations.

NEW IDEAS FROM FARNBOROUGH

Hydraulically Powered Vibration Generators

Versatile high-thrust vibration generators, hydraulically powered and substantially lower in cost than existing electromagnetic units, were among the more outstanding exhibits at the recent Society of British Aircraft Constructors' display at Farnborough. These units, shown by Dowty Rotol Ltd., have been introduced for three different duties: (1) push-pull fatigue testing machines; (2) "shake" test vibrators for medium frequencies; and (3) hydraulic loudspeakers for applying high-energy audible vibration. Frequency variation is controlled by Dowty-Moog servo valves, to which appropriate electrical signals are fed and converted into an accurately controlled hydraulic output. Hydraulic power is supplied by a battery of Dowty hydraulic power packs; these packs are available as units with 1½-10 b.h.p. motors, and pump outputs of from 2-8 gall./min.

Dowty-Rotol fatigue-testing machines will be made in load ranges up to 100 tons total thrust. The equipment may be used to apply a preload, either tensile or compressive, up to maximum thrust; an alternating load may be superimposed on the preload provided that the maximum applied load is within the maximum thrust of the unit. Frequency range is from zero to 100 c/s, and as well as straight load cycling tests at a predetermined fixed frequency, the equipment has the ability to use a random programme fed in by tape or other input means.

The vibrator for carrying out shake tests comprises a pedestal on which a table for carrying large specimens can be mounted. Loads up to 75,000 lb. can be vibrated at frequencies from zero to 500 c/s, and again random programming is possible. This equipment can be used for resonance testing of all types of machines and structures—it has in fact been used for resonance search tests on a dam in Holland.

The hydraulic loudspeaker, with a frequency range from zero to 1,600 c/s, provides a noise generator capable of much higher energy levels than electronic noise generators. One of the uses for which this equipment has been designed is the reproduction of jet-efflux fatigue effects on aircraft structures in the laboratory.

Vibration Isolation

From the generation of vibrations we turn to their suppression: Delanay Gallay Ltd. have introduced a new method of vibration isolation and shock protection, known as Vibrashock Isolation (see Fig. 1). Developed in the first place for missiles and aircraft, the range of isolators has been extended to cover land vehicles, and marine and industrial applications.

Conditions of environment dictated the exclusion of organic materials; Vibrashock Isolation is of all-metal construction. The damping medium consists of stainless steel wire knitted into a mesh, which is then crimped and rolled into a cylindrical cushion. The cushion is then compressed beyond its elastic limit in a suitably shaped die.

Cushions fabricated in this way act as variable-rate variable-damped steel springs. Mounted as anti-vibration mountings, they have a minimum deflection under increasing load due to the variable rate characteristic, and also maintain substantially constant natural frequency under such varying loads. At high frequencies and low amplitudes impedance due to damping is at a very low level; whereas under low-frequency excitation, where greater amplitudes are experienced, the damping characteristic increases. Both spring rate and damping rate can be varied within quite substantial limits by the adoption of different mesh structures, and by varying other parameters. Extremely small compact mountings can carry very high loads, resulting in large savings in equipment weight, cost and design effort.

In general, although a standard range of mountings is available, Delanay Gallay's policy is to consider the circumstances of each individual application and to work out the best solution for that particular problem. The unit shown in the illustration is designed for industrial applications such as mounting compressors, power presses and generators.

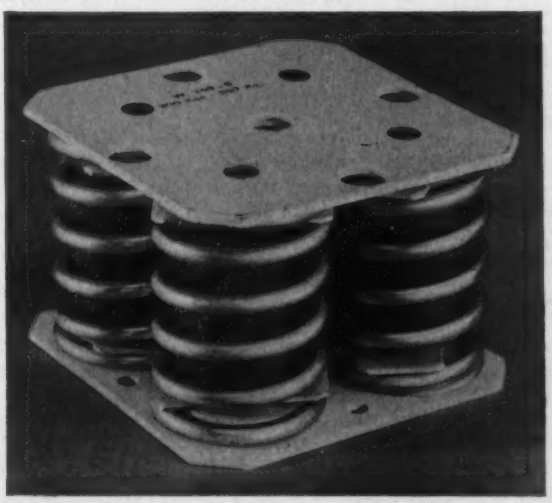
Stainless Steel Bellows

A flexible stainless steel bellows which can compress into 50% of its length was shown by Power Auxiliaries Ltd. It has been designed for a hydraulic accumulator for missile applications, to replace the existing rubber accumulator which, although completely satisfactory in performance, has a limited storage life. The bellows is made of stainless steel sheet 0·016 in. thick, convoluted and then seam-welded. Operating pressure is 1,500 p.s.i. At present the fatigue life of the unit, which is still under development, is not adequate for airframe applications, but ultimately it is intended to develop it for wider applications than missile service.

Switches

Some interesting new switches have been introduced by Dowty Electrics Ltd. Their DN 1260Z range of toggle switches has been designed to meet the latest Ministry of Aviation specifications. Four basic units are available: one, two, three and four pole, each fitted with heavy-duty contacts capable of switching 20 amps. resistive at 28 volts d.c. All versions can be fitted with a variety of contact arrangements covering both two- and three-way operations, i.e. the switch may be used as a three-way selector. A lever movement of

Fig. 1. Heavy-duty industrial Vibrashock Insulation all-metal anti-vibration mounting. (Delanay Gallay Ltd.)



±24° gives clear indication of the position of the switch.

The operating dolly can have three positions: up, central and down, or two positions, the latter being any pair of the three positions. Normally the dolly will remain at the setting at which it is released, but it can be fitted with a spring return to central operating from either or both sides. In such cases spring return over the full travel will not cause dolly overrun or contact bounce. A further variation to the lever movement is the fitment of a dolly which will lock at a selected setting until raised and held against its loading spring, this taking a pull of about 3½ lb. The locking action can be applied to any one, two or three settings. Synthetic rubber seals round the base of the dolly shaft seal the interior of the switch against the entry of moisture and dust.

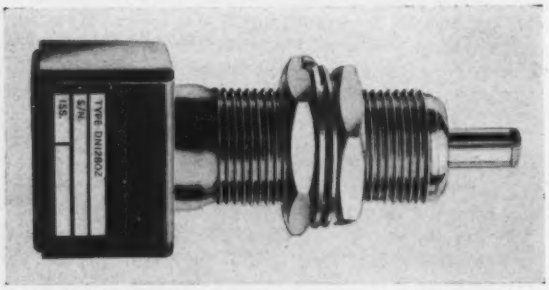


Fig. 2. Hermetic sealing and low operating loads are the main features of the Picaseal microswitch. (Dowty Hydraulics Ltd.)

The mechanism incorporates a very firm detent, and operates with a decisive snap action. If the dolly is operated slowly, the contact pressures remain at maximum until the dolly reaches its critical point after 12° movement. A further 1° movement will cause the contacts to change over as the mechanism includes a secondary positive drive which is capable of breaking a light weld between contact faces.

Hermetic sealing and low operating loads are the main features of the new Dowty Picaseal microswitch (shown in Fig. 2), which is designed to operate in ambient temperatures ranging from −75 to +70 deg. C. and at altitudes from sea level to 60,000 ft. No organic materials are contained within the sealed switchbox. The snap action, double-pole switch is assembled on to contact posts which pass through glass/metal seals in a steel baseplate. Operation is by means of a dolly sealed at its pivot by a brass bellows to complete hermetic sealing of the contact chamber. The upper end of this dolly engages a hollow cone profile in the stainless steel operating plunger. Depression of the plunger moves the dolly about its pivot, causing operation of the contacts by the lower end of the dolly. Further depression of the plunger moves the top of the dolly into a hole in the plunger, thus providing overtravel.

The operating plunger passes through a dynamic seal. Thus the compartment of the switch containing the return spring plunger bearing and upper portion of the dolly is sealed to "environment free" standards. At 60,000 ft. the force on the plunger required to operate the switch is 10 lb., rising to only 11·5 lb. at the full plunger overtravel of $\frac{1}{8}$ in. At sea level the minimum plunger release force from the switch operating position is 5 lb.

Switch operating characteristics are as follows: distance to operate 0·030 in. plunger movement; simultaneity of contact operation, 0·005 in. plunger movement; contact differential, 0·017 in. plunger movement; contact rating per contact set, 4 amps. resistive at 28 volts d.c. Terminations are provided by flying leads, number coded and 6 ft. in length.

The switch turret is threaded $\frac{1}{4}$ in. dia. 24 UNEF thread over a length of $\frac{1}{16}$ in. to provide means of mounting. The weight of the switch complete but without flying leads is 2¼ oz.

Rotary Disc Atomiser

Spinning disc distributors have been used in a variety of applications for the uniform distribution and atomisation of a fluid. The technique is of interest to gas turbine designers as a means of distributing fuel evenly around the combustion space in order to achieve a uniform gas temperature at the entry to the turbine. This uniformity of temperature is a major factor influencing the power and life obtainable from the engine.

For this reason a detailed study of a spinning disc distributor is being carried out at the National Gas Turbine Establishment, and the result of some of their work was on view at Farnborough (see Fig. 3). As part of this study they have measured the variation of the thickness of the liquid film over the disc surface, and the effects of changes in liquid flow rate and disc speed.

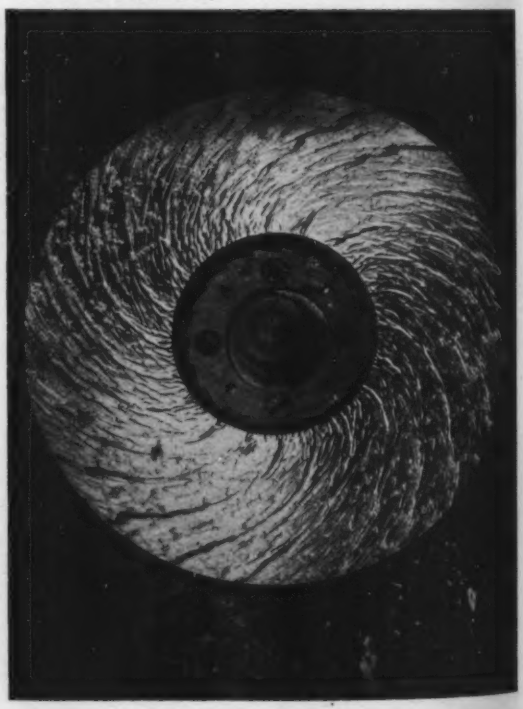
The film thickness has been measured by means of an electrical resistance technique using a special disc having several concentric insulated electrodes embedded in its surface. By measuring the electrical resistance between adjacent electrodes when the disc face is covered with a film of electrolyte (sodium carbonate), the mean film thickness can be deduced.

Film thicknesses in the range 8 to 500 microns (approximately 0·003-0·02 in.) have been measured, and it has been shown that the thickness $\triangle$ at any radius R can be related to the liquid flow rate and rotational speed ω by an equation of the form:

$$\log \triangle = k \log Q/\omega^2 R^2$$

The work is being continued to investigate more fully the influence of the method used to introduce the liquid into the disc hub, for the work to date has shown the importance of the flow pattern in this region.

Fig. 3. Spinning disc fluid distributor test rig for determining thickness distribution of the liquid film. (National Gas Turbine Establishment.)



METAL-BONDED GRAPHITE

Ford Manufacturing Co., of the U.S.A., have developed a new metal-bonded graphite material exhibiting improved mechanical properties. The following article outlines the process of manufacture, and potential applications, of this material

THE unique properties of graphite permit it to be used in a wide variety of anti-friction, electrical and refractory applications. However, as an engineering material, graphite suffers from two serious deficiencies, namely, brittleness and low strength. In some cases, the anisotropic mechanical and physical properties of moulded graphite are also an undesirable feature.

In the field of bearing applications, efforts have been made to utilise the low friction property of graphite, and the more desirable mechanical properties of metals in a composite metal-graphite system. The processes generally employed for the fabrication of metal-rich compositions include solid state sintering of preformed powder mixtures, and hot pressing of powder mixtures. For graphite-rich compositions, one process involves the pressure infiltration of liquid metal into graphite skeletal structures. Graphite-rich compositions are also prepared by moulding metal-graphite mixtures containing a pitch binder, particularly for electrical applications such as commutator brushes. The moulded compositions are subjected to a heat-treatment to carbonise the organic binder, and since the strength is dependent on carbon-graphite bonding, the resultant product is relatively low in strength and brittle. The process used for the fabrication of these materials utilises conventional powder metallurgy cold-forming techniques and liquid phase sintering, which heretofore has not been possible because of the poor compatibility of liquid metals with graphite.

Liquid Phase Sintering

Liquid phase sintering of preformed powder compacts is a technique that is employed in such well-known polyphase systems as iron-copper, copper-nickel-tungsten, and the cemented carbides. It offers the advantages of high sintering rates, and a rapid approach to equilibrium structures. In the compositions cited, liquid phase sintering is no particular problem when contrasted with systems such as the oxide base cermets. In the latter case, it is not unusual to observe a "sweating" of the liquid metal from the compact during the course of sintering. Unfortunately, this "sweating" tendency also occurs in metal-graphite systems.

The macroscopic phenomenon of "sweating" is attributed to the poor wettability of the solid by the liquid, which in turn is a manifestation of the quantitative relationship between the various interface energies acting on the system. Accordingly, it is necessary to improve the wettability of graphite in order to successfully liquid phase sinter metal-graphite compacts containing iron, nickel, cobalt, copper, silver or aluminium. It was also shown that wetting could be enhanced only by decreasing the solid-liquid interface energy. Since surface energies can be markedly influenced by small concentrations of surface active impurities, one approach to decreasing the liquid metal-graphite interface energy is to introduce surface active alloying additions.

In this connection it was suggested that additions of nodulising agents such as cerium, calcium, magnesium and barium to iron-graphite compacts might be effective in promoting the necessary wetting to permit liquid phase sintering techniques to be employed. Subsequent sintering studies on iron-graphite compacts proved this hypothesis to be valid, and it was found that optimum results were obtained with calcium additions in the form of a powdered calcium-silicon alloy containing approximately 35% by weight of calcium. Additions of calcium-silicon as low as 0·1% by weight of the metal phase were effective in inhibiting sweating of the liquid phase during sintering.

Since the calcium was added in the form of a calcium-silicon alloy, a study was made on the possible influence of silicon additions to iron on the wettability of graphite. The data obtained on the iron-carbon-silicon system indicate that the improved wetting of graphite resulting from calcium-silicon additions can be attributed only to the presence of calcium.

Iron-bonded Graphite

Although to date a variety of metal-graphite compositions have been successfully liquid phase sintered, including iron, nickel, cobalt, copper, silver and aluminium-graphite, the most extensive data have been obtained on iron-graphite compositions containing calcium-silicon additions.

The strength of the iron-graphite composition was determined both in cross bending and compression. Fig. 1 shows the influence of calcium-silicon additions, based on percent-

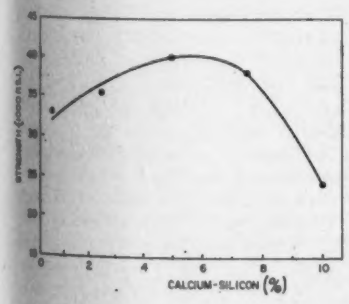


Fig. 1

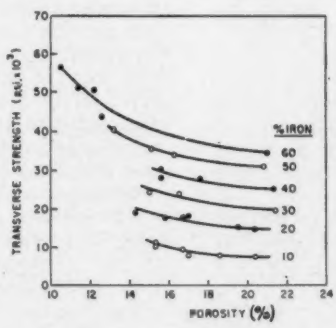


Fig. 2

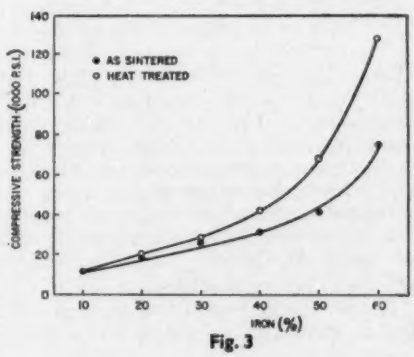


Fig. 3

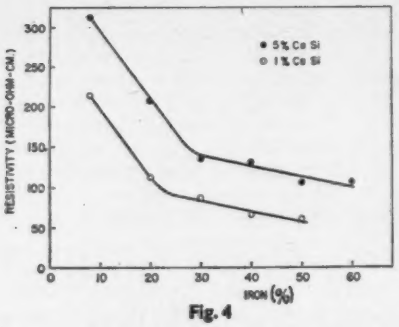


Fig. 4

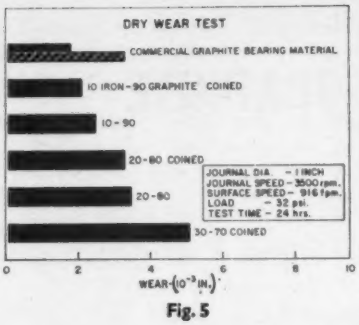


Fig. 5

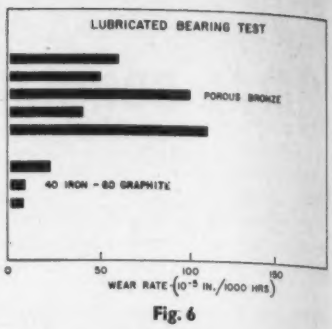


Fig. 6

age by weight of the iron phase, on the bend strength of a 50% Fe/50% graphite composition (by volume). It can be seen from Fig. 1 that an optimum strength is obtained with approximately 5% calcium-silicon. A more extensive evaluation of the bend strength of iron-graphite compositions containing 5% calcium-silicon is shown in Fig. 2 as a function of the volume percentage iron and porisity. For the graphite-rich compositions, the strengths are equal to and superior to the best obtained on pure graphite materials, while for the metal-rich compositions the strengths compare favourably with the best obtained in the porous metal compositions used for bearing applications. Although no precise elongation measurements have been made, compositions containing in excess of 40% iron by volume showed permanent deformation during bend tests, and all compositions, including the 10% Fe/90% graphite, could be successfully subjected to secondary coining operations.

The compressive strengths for compositions of variable iron content are shown in Fig. 3 for both as-sintered ferritic and heat-treated martensitic structures. Heat-treatment consisted of austenitising at 1,010 deg. C., oil quenching, and tempering at 205 deg. C.

From the compressive strength data in Fig. 3 it is interesting to note that although the strength of the metal phase is increased substantially by heat-treatment, this has little effect on the strength of the composite material for compositions below 30% iron by volume. A possible explanation may involve a change in the metal phase continuity at this level, and consequently a change in fracture path. An indication of a change in metal phase continuity with increasing metal content is obtained from resistivity measurements (see Fig. 4) which show an abrupt change in slope at about the 30% metal level.

With regard to potential applications of the metal-bonded graphites, the field receiving most attention at this time is that of bearing materials. With the broad range of compositions available, these materials are being considered for both dry and externally lubricated bearing environments. Fig. 5 illustrates the results of preliminary studies on the wear of graphite-rich iron compositions and commercial graphite bearing materials riding dry on a steel journal under the conditions shown. It can be seen that the wear of the graphite-rich compositions is in the same range as the graphite materials. Assuming an equivalent overall bearing performance for the two materials, the advantages offered by the metal-graphite compositions are improved mechanical properties, the use of high volume powder metallurgy production techniques, and close dimensional control of parts by means of secondary sizing operations.

In the field of bearing materials for operation in an environment providing external lubrication, one type of application involves the use of oil-impregnated porous metal bearings. Oil impregnation studies on the metal-graphite compositions showed that the porosity in these materials is continuous, consequently applications utilising self-lubricated oil-impregnated bearing are immediately suggested. The results of comparative wear rates of oil-impregnated porous bronze and 40% Fe/60% graphite materials, evaluated as fractional horsepower heater motor (automotive) bearings, are shown in Fig. 6.

Although the test conditions were not particularly severe, the results do indicate a lower wear rate for the iron-graphite compositions. For the porous bronze materials the p.v. value is reported to be about 50,000. Preliminary results on iron-graphite indicate that p.v. values approaching 200,000 may possibly be attained.

BRASS PLATING OF TITANIUM

RUSSIAN scientists have developed a method of brass-plating the surfaces of titanium components. The method uses a combination of electro-plating and a subsequent diffusion treatment, and produces a deposit with good adhesion and the anti-friction properties of brass.

The first step in the treatment is the preparation of the titanium surface before electro-plating. Trials with several methods of pickling have shown that a satisfactory surface preparation is obtained by pickling in a concentrated hydrochloric acid at a temperature of 15 deg. C. during 1 hr. Before pickling, the surface of the specimen is degreased with chalk and washed in water.

Following earlier investigations by Japanese scientists, it was concluded that a protective film is formed, consisting of titanium hydride, which prevents oxidation and possesses good conductivity.

Copper-plating was carried out in a standard acid electrolyte containing copper sulphate and sulphuric acid. Plating was carried out at a temperature of 18-20 deg. C. and a current density of 1-2 amps./sq. dm.

After a series of tests, it was found that a special technique was required to obtain copper deposits of arbitrary thickness with good adhesion. A deposit of 15-20 microns was plated. The specimen was then subjected to annealing in vacuum (at less than 1 micron mercury column) at a temperature of 800 deg. C. for 1 hr. Additional copper can be deposited to any desired thickness after the treatment and passivation in a solution of nitric and hydrochloric acids. The total copper deposit can reach 1 mm.

The copper deposit was converted into brass by diffusion at a temperature of 730-750 deg. C. from a mixture consisting of zinc powder, fireclay powder, ferro-sillicon and ammonium chloride. Tests, in an Amsler friction machine, of the deposit thus obtained for its anti-friction properties have shown that the brass deposit behaves like ordinary brass. With lubrication, a coefficient of 0·08 was measured.

WHAT'S NEW IN MATERIALS

Adhesive-coated Copper

A new laminating adhesive coated copper manufactured in the U.S.A. is now available in this country in four grades including 1 oz. and 2 oz. per square foot. The material is claimed to conform fully with NEAMA specifications and tolerances, and to be suitable for laminates of paper-phenolic or epoxy-paper-glass construction. The copper is claimed to have a minimum purity of 99.5% and the thickness is 0·0014 in. for 1 oz. and 0·0028 in. for 2 oz. per square foot material. *Omni-London*, 35 Dover Street, London, W.1.

EMD 7761 for further information

Skin Cleansers

Kerocleanse No. 23 is a cleanser which removes deposits without damaging the skin in any way. It is said to remove oils and similar materials very readily, and after application can be wiped clean with a dry cloth or in fresh or sea water. It can also be used on the face if required.

Kerocleanse Nos. 25 and 26 are said to be effective for removing a variety of synthetic adhesives and cements based on rubber and plastics products from the skin. No water is required in using either of these cleansers, which are simply applied to the hands and rubbed vigorously when the adhesive balls up. The hands can be wiped clean with a cloth.

Kerocleanse No. 22 can be used for cleansing synthetic resins from the skin, and No. 21 for removing stains. *Scientific Pharmacals Ltd.*, Technical Advisory Department, 1 Eden Street, Hampstead Road, London, N.W.1.

EMD 7762 for further information

Respatex Decorative Laminate

Respatex F.1 is a high-pressure decorative laminate made from several layers of special paper impregnated with phenolic resins and other materials. The two top layers of paper, however, are impregnated with melamine resins, which give colour fastness and hardness to the laminate. The material complies with N.E.M.A. standards for high pressure laminates. A weight of 1 ton dropped from a height of 2 ft. makes no impression on it; the water absorption after 24 hr. immersion is 1·2 per cent; it is light in weight, and has high abrasion resistance and excellent colour fastness.

Respatex F.1 has been subjected to an extensive fire test by the Department of Scientific and Industrial Research and Fire Offices' Committee, Joint Fire Research Organisation. The object of the test was to classify the material according to its surface spread of flame in accordance with BS 476, Pt. 1 : 1953. The work showed that no surface flaming occurred on any of the specimens. The material may therefore be used with complete confidence as a laminate in any engineering applications where a fire hazard is likely to exist. *Getz Bros. & Co.*, 52 Jermyn Street, S.W.1.

EMD 7763 for further information

Plastics Putty

Talurit plastics putty is a new material which, though malleable, when formed sets rock hard. It is an efficient electrical insulator and can be machined, drilled, tapped or threaded. It can be used to repair almost anything, and is suitable for sealing cracks and holes in all types of hollow piping.

The new plastics putty consists of two separate components—a resin and a hardener. When these two are completely integrated in equal proportions (which is easily effected in the hands), a readily workable putty is provided that will adhere to anything. It cures naturally in anything from 1¼ to 18 hr. according to the room temperature. Independent tests from a

Talurit plastics putty used for the electrical insulation of a metal-handled ring spanner.

number of representative samples have provided the following results: compressive strength (ult.) 11,200 p.s.i.; tensile strength (ult.), 700 p.s.i.; dielectric strength, 253 volts/mil.; resistance between electrical conductors and armour, 37,300 megohms; resistance between electrical conductors and water, 27,850 megohms; and water absorption, 2.7%.

Some of the electrical applications of Talurit putty include the setting and affixing of shrouding, insulating or waterproofing terminals, conductors or cable ends; cable joints; and repairing or replacing porcelain and plastics insulators, bushes and terminal blocks. Among its mechanical applications are the structural joining of materials and components; repair of leaks and weaknesses in vessels, piping or casting; and for all purposes where the putty, when cured, will require drilling or tapping to receive a stud or similar component. *Cable Covers Ltd.*, St. Stephen's House, Westminster, S.W.1.

EMD 7764 for further information

Polyurethane Rubber for Mechanical Applications

Daltoflex 1 is a polyurethane raw rubber designed for processing on conventional rubber machinery. It is cured by means of Suprasec M, a liquid isocyanate compound of high boiling point whose low vapour pressure ensures freedom from any toxic hazard during processing. Hard rubbers of outstanding physical and chemical properties are obtained.

Curing is normally carried out under pressure at 150 deg. C. for 10-20 min., followed by a short oven cure at 110 deg. C. With these new products, in contrast to natural rubber or other synthetic rubbers, an accelerator is not essential for curing. The cured compounds obtained are said to be markedly superior to natural and earlier synthetic rubbers in tensile and tear strength, abrasion resistance, solvent resistance and in resistance to oxidation.

Daltoflex 1 compounds are claimed to be highly suitable for such articles as oil seals, shoe soles and heels, solid tyres for factory trucks, diaphragms, and for general mechanical applications where a a high level of physical properties and/or good solvent resistance is necessary. Unlike cast polyurethane rubbers, the compounds may be considerably reinforced by filling with carbon black, silica or other fillers, using conventional rubber-processing techniques. *Imperial Chemical Industries Ltd.*, Imperial Chemical House, Millbank, London, S.W.1.

EMD 7765 for further information

Flexible Metal Tubing

A flexible metallic tubing with a design pressure as high as 2000 p.s.i. for use in ambient temperatures up to 400 deg.C. involved a great deal of experimental research and development, and the construction of a completely new tube making plant. The tubing produced as an outcome of these efforts is of the all-metal corrugated type made from titanium stabilised stainless steel, corrosion resistant and weld-decay proof material having strength for operating under high and low temperature and pressure conditions, yet retaining a remarkable degree of flexibility. Corrugations are annular in form and are shaped with a minimum of metal stretching. External armouring is provided by way of stainless steel wire braiding in an improved form of weave devised for the dual purpose of ensuring constant strength greater than hitherto, and at the same time reducing elongation under pressure almost to the point of elimination.

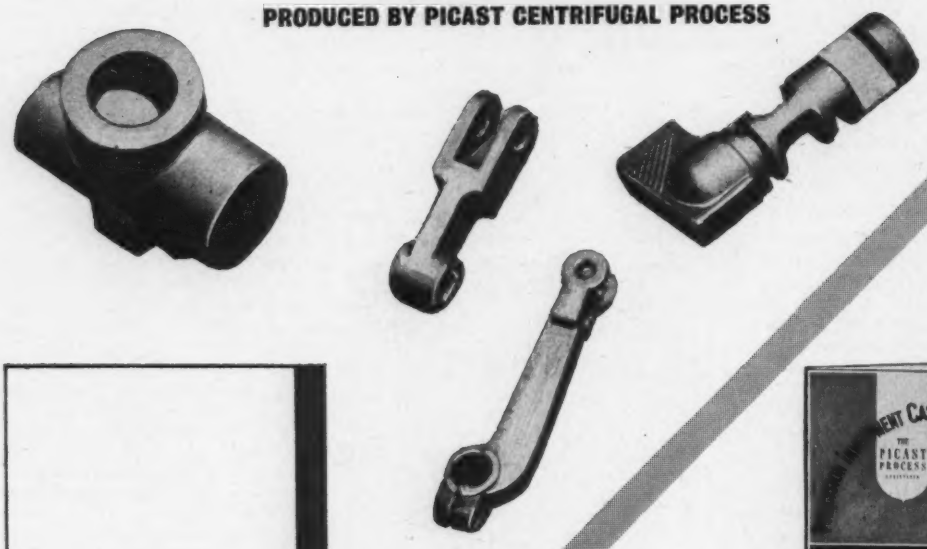
A new range of compact light weight end connections in stainless steel has also been designed, and attachment to the tubing is by direct Argon-arc welding. The tubing when cut to length presents a continuous surface due to the annular form of corrugation to which connections may be most efficiently welded. Since the assemblies of tubing with fittings are all metal construction throughout, no washers or seal are required. *Power Flexible Tubing Co. Ltd.*, Derby Works, Vale Road, London, N.4.

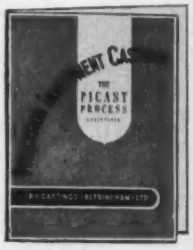
EMD 7766 for further information

EMD 7681 for further information

PICASTINGS
save machining costs

INVESTMENT CASTINGS
PRODUCED BY PICAST CENTRIFUGAL PROCESS





Leaflet P.I.2 gives full details of the P.I. Castings process. Send for a copy today.

Design Advantages

* Elimination of assembly
* Complex or simple shapes
* Small or large quantities
* Uniformity of material structures
* Thin sections in high melting point alloys
* Reduction of secondary machining operations
* Freedom in choice of materials

P. I. CASTINGS (ALTRINCHAM) LTD
ATLANTIC STREET, ALTRINCHAM, CHESHIRE
Telephone : Altrincham 2702 (5 lines) Grams: Precisely, Altrincham
Telex 66-105 – A/B Atlantic Altchm.

PI 7

WHAT'S NEW IN MATERIALS

Epoxy Resin Powders

Where high electrical insulant properties are required together with resistance to heat, as well as to moisture and other corrosive elements, the development of epoxy resin powders as a dip-coating medium is of interest.

The coating obtained by epoxy resin powders is said to have all the outstanding protective qualities of epoxies as applied by other well-proved techniques. Among the advantages conveyed by fluidised bed powder coating as a method of application are speed and low wastage. One of the spheres in which the properties of epoxy resins are most advantageous is that of the coating of electrical and electronic apparatus, notably in the insulation of stators and other components of motors. *Telcon Plastics Ltd.*, Green Street Green, Orpington, Kent.

EMD 7767 for further information

Glass-fibre Insulated Flexible Cable

A flexible glass-fibre insulated cable for use as a light fitting connection is now available. The new cable, which is suitable for 250-volt operation, is specially designed to function at the high temperatures likely to be encountered in contemporary lighting fixtures used for illumination in modern office blocks, large stores and in enclosed show-cases.

In its natural state, the glass fibre used for the insulation—treated with a suitable form of varnish binder and filler—will not burn or carry flame. Should the cable be subjected to an external source of heat, with a temperature of up to 180 deg. C., the insulation and conductor are claimed to remain intact, permitting a continued flow of electricity. *British Insulated Callender's Cables Ltd.*, 21 Bloomsbury Street, London, W.C.1.

EMD 7768 for further information

Copper Foil for Copper-clad Laminates

A new range of printed circuit grade electrodeposited copper foils, coated with a dry thermosetting adhesive film, is announced. Produced in three weights—1, 2 and 3 oz. per sq. ft.—the new materials are claimed to offer an impressive list of advantages over existing materials to manufacturers of copper-clad laminates.

Rigorous control during processing ensures uniform high quality of both copper foil and adhesive, and the foil is sheeted to customer specification, thus eliminating all waste. Precision coating gives an adhesive thickness tolerance of ±0·001 in. Under normal storage conditions performance characteristics are said to remain unaltered after many months of storage. The foils are claimed to give high bond strengths and high solder-dip resistance, and to have excellent electrical properties. *Fothergill & Harvey Ltd.*, Sladen Wood Mill, Littleborough, Lancs.

EMD 7769 for further information

Gallium Arsenide

Sample quantities of this intermetallic compound are now offered in polycrystalline form. It is also hoped that single-crystal material will be available shortly.

Typical properties of polycrystalline gallium arsenide are given below:

Resistivity	0·01-0·2Ω-cm.
Hall coefficient	50-250 $cm.^3/C$
Electron mobility	2,000-4,000 $cm.^2/V.s$
Carrier concentration	$1\text{-}30 \times 10^{16}/cm.^3$

The material is available either as broken ingot or cut slices. *Johnson, Matthey & Co. Ltd.*, 73-83 Hatton Garden, London, E.C.1.

EMD 7770 for further information

Metal Treatment Process

Luster-on 70 is a simple 20 seconds, fumeless, chemical dip process for copper, brass and bronze products. By passivating the surface, it provides resistance to corrosion, staining and tarnishing, and a degree of brilliant lustre.

The new process is ideal as a final finish or as a pre-treatment prior to plating.

At it is non-fuming no ventilating equipment is needed whilst it is claimed that processing can be calculated in fractions of a 1d. per square foot. *Tool Treatments (Chemicals) Ltd.*, Colliery Road, Birmingham Road, West Bromwich, Staffs.

EMD 7771 for further information

Yellow Polyester Thermosetting Tape

An opaque polyester thermosetting self-adhesive tape has been introduced to meet applications which require a high-temperature tape of distinctive colour. Like the transparent polyester thermosetting tape, the yellow has good solvent resistance, and is free from staining tendencies. After curing, the tape will operate in temperatures up to 180 deg. C., and has a breakdown of 5,000 volts.

A high degree of solvent resistance is obtained by curing at 150 deg. C. for 1 hr. and 120 deg. for 2 hr. Maximum solvent resistance is achieved by curing for double these periods. *Paynes Jiffytape Ltd.*, Haydn Road, Nottingham.

EMD 7772 for further information

Adhesive Felt

Adhaesium is an impregnated felt claimed to provide a means whereby machinery of any size can be fixed to the factory floor without the need for bolting. It is only necessary to make sure that the base of the machine is free from oil, grease, dirt or water, and then to cut a length suitable to fit beneath each foot of the machine, leaving ½ in. projecting. The machine is then lowered into position and is ready for use the following day. The floor is said to be undamaged when the bond is broken and the machine removed. *Carlton Brown & Partners Ltd.*, 15 Lower Queen Street, Sutton Coldfield, Warwickshire.

EMD 7773 for further information

Acoustic Tile

Blue Hawk Acoustic Tiles are attractive, lightweight and intended not only to improve acoustics but also to enhance the appearance of the building in which they are installed.

The face of each tile is broken by a series of slots and the edges of the tiles are bevelled on the face and reverse. In this way an attractive design may be created by reversing some of the tiles where acoustical conditions permit. The tiles are supplied in white but the surface may be painted if required.

The tiles are made of a porous material, light in weight. Each tile is 12 × 12 × $1\frac{1}{16}$ in. and weighs approximately 1¼ lb. *The British Plaster Board (Manufacturing) Ltd.*, Ferguson House, 15-17 Marylebone Road, London, N.W.1.

EMD 7774 for further information

Polyester Resins containing Isophthalic Acid

Two types of isophthalic resins are now available under the references Beetle Resin L.2016 and L.2051, the former being recommended for hand lay-up and the latter for gel coating purposes. The improved properties of these resins give scope for their use in the production of putty compositions for the patching and repair of car bodies, etc. The main advantage is their exceptionally good adhesion to metal when compared with the more orthodox resins. Their improved resilience minimises any tendency to cracking and crazing on flexing. The heat resistance of resin L.2016 is also sufficient for the cured body putty to withstand the normal baking cycles used with synthetic paints. *B.I.P. Chemicals Ltd.*, Oldbury, Birmingham.

EMD 7775 for further information

Free-machining Aluminium Alloy

C80 Superspeed is a medium-strength heat-treatable aluminium alloy containing small additions of lead and bismuth evenly dispersed as fine particles throughout the material. These particles act as chip breakers, the resulting small chips falling away from the cutting tool during machining, thus preventing build-up of swarf between tool and workpiece. Chips from the alloy usually form only a single loop before breaking, which eliminates the need for tools with expensive chip breakers.

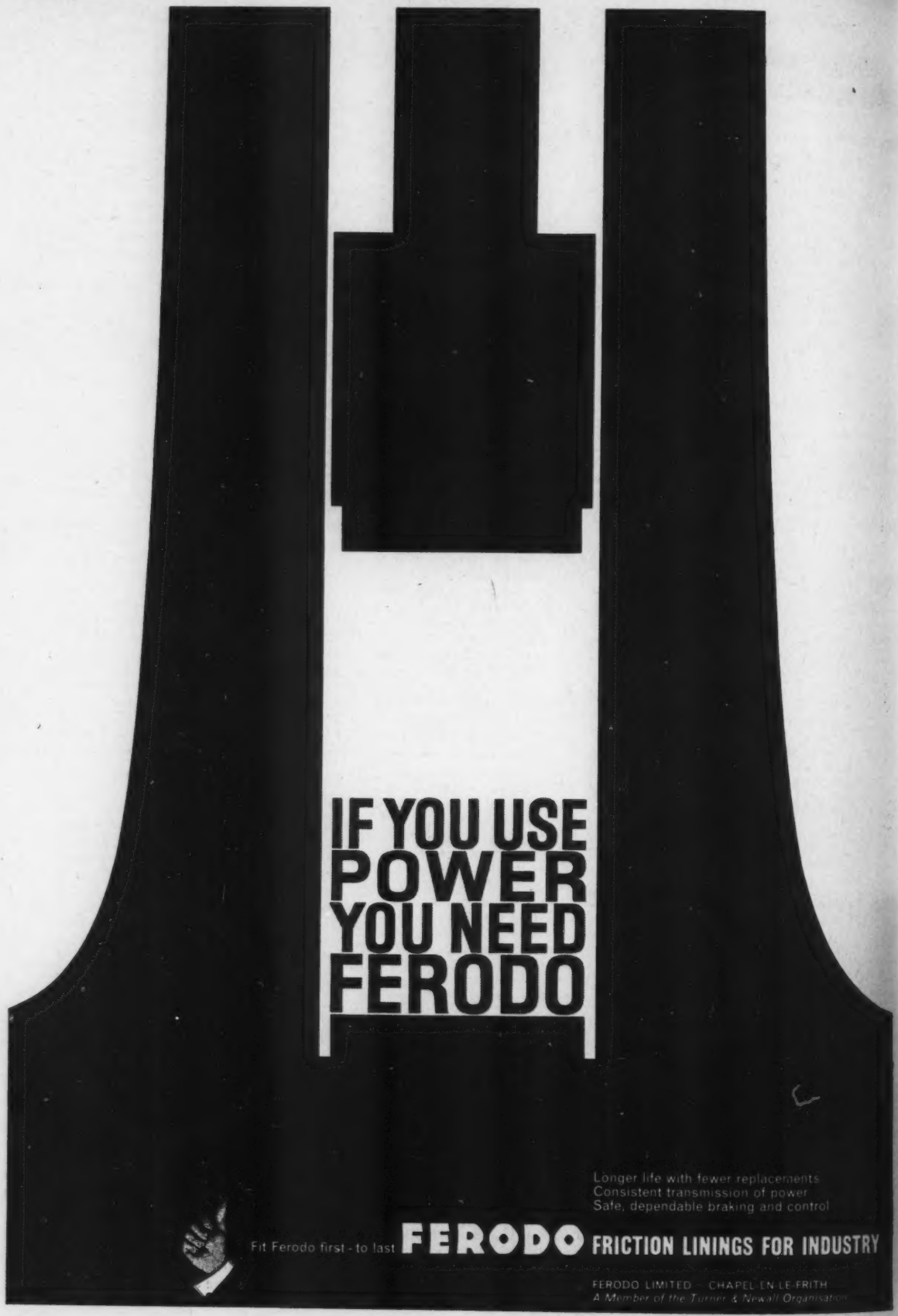
C80 is available in rounds of 0·12-3·0 in. dia., and in hexagons from 0·3-2·22-in. a/f, and is said to be particularly suitable for the high-speed production of turned components on turret and automatic lathes. *Imperial Aluminium Co. Ltd.*, P.O. Box 216, Witton, Birmingham 6.

EMD 7776 for further information

Please Note!

We receive many reader enquiry cards on which the reader has omitted to fill in his name and address. In order to avoid disappointment we remind readers that names and addresses should be included on each card.

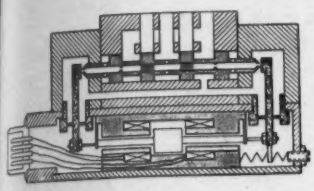
EMD 7682 for further information


IF YOU USE
POWER
YOU NEED
FERODO
Longer life with fewer replacements
Consistent transmission of power
Safe, dependable braking and control
Fit Ferodo first - to last
FERODO FRICTION LININGS FOR INDUSTRY
FERODO LIMITED · CHAPEL-EN-LE-FRITH
A Member of the Turner & Newall Organisation

WHAT'S NEW IN COMPONENTS

Servo Valves

Pegasus Servo Valves are high performance units designed for industrial, aircraft and missile applications. The indus-



trial valves are of compact design and rugged construction. Flow capacities range from 5 to 160 g.p.m. at 3,000 p.s.i. The units for aeronautical application have flow ranges of 2 to 5 g.p.m. at 3,000 p.s.i.; special attention has been given to the weight factor, enabling the largest unit of the range to be produced weighing only 15 oz. *Telehoist Ltd.*, Manor Road, Cheltenham.

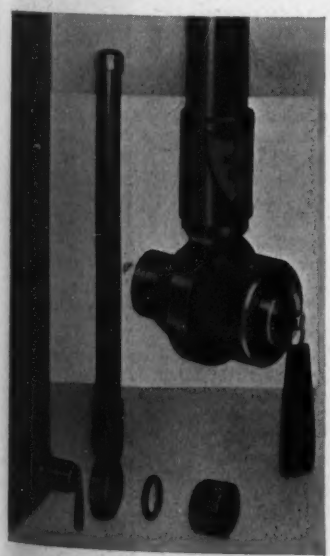
EMD 7777 for further information

Safety Liquid-level Gauge

A lightweight gauge for reliably measuring the contents of domestic central-heating oil tanks is fitted with a special spring-loaded pull button valve which only allows liquid into the gauge when manually operated at the time of the gauge reading, and completely shuts off the contents of the tank from the gauge sight tube when not in use. The gauge can be removed from the tank for cleaning and inspection while the tank remains full.

The sight tube is constructed in a clear unbreakable plastics material, and is provided with special plastics strip giving effective optical magnification of liquid level. *Seetru Ltd.*, Corn Street, Bristol 1.

EMD 7778 for further information



Oil Meter for Low Flow Rates

An oil meter which can measure accurately the flow of fuel oil at rates as low as 1¼ gall./hr. under heads as low as

2 ft. is now available. Previously it has not been possible to measure such low rates of flow with this standard type of instrument. Primarily intended for the measurement of the flow of fuel oil to burners, the meter is claimed to provide for the first time an economic means of recording such information on many of the smaller industrial applications such as oil-fired boilers, furnaces and ovens.

The instrument, which is of the integrating type, is a specially calibrated version of the company's standard ¼ in. Arkon oil meter, which is normally calibrated to read flows down to 4 gall./hr. An inherent feature of the design of this meter is its nutating piston principle—a flat disc oscillating on its periphery—which makes it extremely sensitive; it is said to be accurate to within ±1%. *Walker Crosweller & Co. Ltd.*, Cheltenham, Gloucs.

EMD 7779 for further information

Long-scale Meter Relay with Front Reset

The Weston Magtrak, now being marketed in the U.K., is claimed to be the first long-scale meter-type relay to provide a manual reset button on the front of the meter case. It can also be reset remotely. Low and high set points are fully adjustable to any position along the 3·86-in. 100° scales. The steel case provides magnetic shielding.

The principal feature of the relay is the unique contact making device, which overcomes the main objection to using indicating instruments for initiating alarm circuits. A soft iron bead on the moving pointer, and the addition of a permanent bar magnet assembly on each adjustable index arm, are the features which operate the relay. When the pointer reaches the control point, the bar magnet pulls in the pointer and moving contact against the flexible index arm contact with a rapid snap action. The force, in the order of 20 to 40 mgm., is sufficient to overcome the contact films, even at low contact voltages. In addition the quick positive contact is claimed to reduce transient arcing, and thus increase contact life and prevent the contacts from welding. *Daystrom Ltd.*, Gloucester.

EMD 7780 for further information

Boxed Springs

A new range of springs, available in boxes, includes four different kinds of contents. Boxes are available containing either light extension, medium extension, light compression or medium compression springs. A chart on the lid of the box enables any particular spring to be selected quickly and conveniently, since it gives full details of outside diameters; free length/length inside loops; number of working coils; wire diameter; rate and load at full compression/extended length inside loops under load; in addition to a simplified method for re-ordering of individual springs. *The Lewis Spring Co. Ltd.*, 122 High Holborn, London, W.C.1.

EMD 7781 for further information

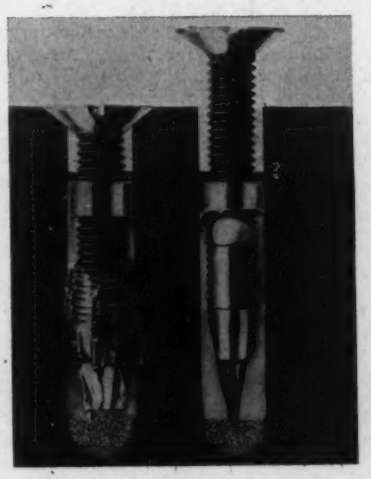
Expanding Masonry Plug

A new masonry plug appears to offer considerable advantages over existing methods of masonry fixing. This new fixing device, known as Obo K-Plug, consists of a cylindrical brass shell filled with a special locking device and tapped to accommodate Whitworth thread machine screws. Three sizes of plug are available, for $\frac{3}{16}$, ¼ or $\frac{5}{16}$ in. dia. screws, which are supplied with countersunk, round or hexagon head in various lengths to suit every application. The plugs are normally supplied assembled with screws ready for fixing.

The unique locking device consists of a hollow tapered brass cone, a cylindrical lead core and a nylon ball. On tightening the screw the brass cone deforms, blocking the plug tip; the lead core is then squeezed out to expand and retain the wings of the plug; the nylon ball is ultimately pushed to the tip of the plug where it rests against the screw acting as a buffer to absorb shock and vibration. The screw itself is partially jammed by the deformed lead to prevent loosening.

Depending on the wall fabric, a $\frac{3}{16}$ in. plug will take up to 900 lb. pull, and a $\frac{5}{16}$ in. plug up to 3,000 lb. Once fixed the plug remains permanently embedded in the masonry, while the screw can be withdrawn as required. *Douglas Kane Ltd.*, 243 Upper Street, London, N.1.

EMD 7782 for further information



WHAT'S NEW IN COMPONENTS

Low-pressure Hydraulic Rams

A new range of hydraulic rams, designated BB by the manufacturer, is designed to operate on oil at a working pressure of

2,000 p.s.i., seven standard bore sizes being available. The largest size has a thrust of 40 tons.

A special design feature of the ram cylinder ensures complete sealing, while the circlip retainer at the front end of the ram simplifies dismantling. An integral circlip between the head of the cylinder is provided to withstand the maximum pressure without the risk of fracturing the cylinder wall. Plain, eye type or screwed rods can be supplied, and the cylinders are available with either trunnion or clevis mountings with feet at top or bottom, and side feet at both ends. *Chamberlain Industries Ltd.*, Staffa Works, Argall Avenue, Leyton, E.10.

EMD 7783 for further information

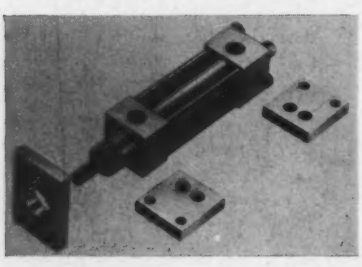
Glass Filament-wound Pressure Vessels

Hystran, a fibreglass reinforced plastics material, forms the medium in which a range of recently introduced pressure vessels are constructed. Both spherical and cylindrical containers are available, and these can be constructed in sizes ranging from 80 cu. in. upwards on a production basis only, and not experimentally. Vessels can be made up to 7 ft. dia. and 30 ft. long, special filament winding machines being available. Hystran, with a density of only 0·072 lb./cu. in., has a tensile strength of 165,000 p.s.i. *Dage (G.B.) Ltd.*, La Casita, Heronsgate, Herts.

EMD 7784 for further information

New Range of Air cylinders

A new range of air cylinders is square-ended and of tie-bar construction. The first sizes to be available are those of ¾ and 1 in. bore in single acting, double acting, and single acting spring return patterns. The cylinders are said to occupy a minimum of space, yet have all the features of high quality construction, such



as stainless steel rods, brass bodies and neoprene distributor type U seals for both rod and piston. All cylinders are provided with screwed nose, front face mounting and rear trunnion mounting, as well as screwed base mounting. Front flange mounting plates or foot mounting plates can be supplied if required. *Air Automation*, 26 Sharrocks Street, Wolverhampton, Staffs.

EMD 7785 for further information

Fuel-oil Pre-heat Indicator

The Shandon fuel-oil pre-heat indicator is designed to take care of any variations in viscosity between one batch of fuel oil

and another which, in the absence of individual viscosity tests, can result in either excessive and uneconomical pre-heating or reduced burner efficiency through under-heating. It is claimed that a viscosity determination—normally requiring laboratory facilities—can be carried out in three minutes by unskilled personnel using the indicator. The correct pre-heat temperature required is read directly from a clearly marked scale—no calculations are necessary.

The instrument consists basically of a steel cylinder approximately 1¼ in. dia. × 9 in. high, standing erect upon a special levelling base and fitted with a perforated plunger carrying the scale rod, which projects above the screw-top of the cylinder. The fall of the plunger in the cylinder is controlled by a cam operated by an oil-filled "falling-ball" timing mechanism. The rod carries five separate scales, for atomising viscosities of 75, 110, 155, 200 and 400 seconds Redwood No. 1 respectively, these covering the requirements of most types of burner in normal use. Pre-heat temperatures for oils of a further seven atomising viscosities can be read from a simple chart supplied with the instrument. *Shandon Scientific Co. Ltd.*, 6 Cromwell Place, London, S.W.7.

EMD 7786 for further information

Pinch-type Valves

The range of Linatex pinch-type valves has now been extended to embrace motorised and pneumatically-operated types. The pinch-type valve has the merit of giving full bore unrestricted flow when open, and is suitable for handling slurries and powders. The valve is glandless, and the basic design greatly facilitates maintenance since it is only necessary to change the rubber sleeve to restore the valve to as new condition.

In most cases, especially when handling abrasive slurries or powders, the sleeve is made from Linatex rubber as incorporated in Linatex pumps, pipe lines and other material-handling equipment. For handling chemicals the valve is fitted with sleeves made from an appropriate synthetic rubber material, including Butyl, Nitrile, Hypalon and Neoprene as dictated by the working conditions. A range of non-return valves and safety/relief valves is also to be marketed. *Wilkinson Rubber Linatex Ltd.*, Camberley, Surrey.

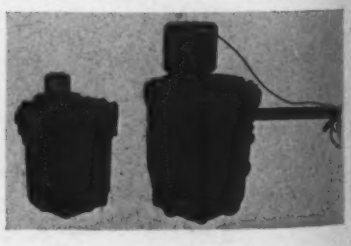
EMD 7787 for further information

New Base Pressure and Volume Indexes for High-pressure Gas Meters

A base pressure index and a base volume index for use with high-pressure gas meters are now available. These indexes are claimed to completely eliminate the need for the complicated calculations hitherto associated with the accurate measurement of gas at high pressures. Briefly, the base pressure index automatically compensates for the gas pressure by mechanically multiplying the volume of gas by the pressure factor, and registers the amount of gas at base pressure which has passed through the meter. The base volume index performs an identical task, but also compensates for temperature.

A supplementary volume and pressure gauge is available for use with both instruments. This gauge plots on a chart the time and pressure at which each thousand cubic feet of gas passes through the meter, thereby providing a permanent record for analysis and reference purposes. *Parkinson Cowan Gas Meters*, Terminal House, Grosvenor Gardens, S.W.1.

EMD 7788 for further information



WHAT'S NEW IN COMPONENTS

Sealed Ball Bearings

The bearing illustrated is a deep groove type recently introduced which incorporates a synthetic rubber seal. The seal is

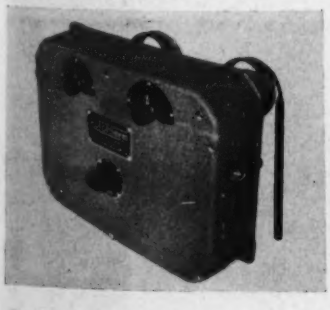
located in the outer race, and makes rubbing contact with the inner race. Where rigidity is required in the seal it is backed by a rigid metal section, but the light rubbing contact with the inner race is said to be unimpaired. Where the bearing is sealed on both sides, it can be supplied lubricated for life with a grease which is effective over a temperature range of −6 to +113 deg. C. The new bearings are available in certain sizes of the 6000, 6200 and 6300 series, and are denoted by the suffixes z1 and zz1 for sealed one side and sealed both sides respectively. *SRO Bearing Co. (Sales) Ltd.*, Camberwell, S.E.5.

EMD 7789 for further information

New Dual-zone Temperature Controller

A new mercury-in-steel on-off temperature controller (Model No. 1039), having independent circuits allowing control at any two points through one instrument, has been produced. Each of the two controller circuits consists of alloy steel Bourdon tubes, capillaries and temperature-sensitive bulbs, operating mercury switches rated up to 30 amps at 230/250 a.c. Indicator lamps and bottom entry electrical conduit are standard. Temperature ranges are available between −20 and +1,000 deg. F. (minimum coverage 100 deg. F.) and the equivalent deg. C. The case is aluminium alloy, and the standard capillaries 10 ft. copper sheathed with mild steel bulbs screwed ½ in. BSP. *British Rototherm Co. Ltd.*, Merton Abbey, S.W.19.

EMD 7790 for further information

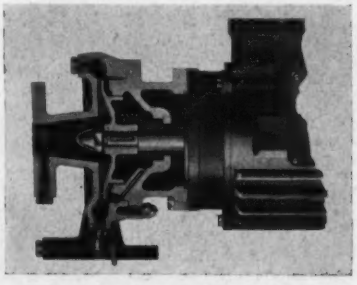


Mopump for General Service

A range of compact close-coupled Mopumps suitable for a large number of applications has been developed. The new range is of all-ferrous construction, and is therefore suitable for filtration, air conditioning, boosting, sump drainage, water softening, sprinkling, refrigeration, washing, condensate duties, mild chemical services, circulating systems and water services of many types.

The general service Mopump is of the single-entry single-impeller type, and since it is fitted with a mechanical seal the shaft length has been reduced to a minimum. Hence the pump is more closely coupled to the motor than usual and the whole unit is very robust. The pump is designed to fit the new compact motors to the dimensions of BS 2960, Pts. I and II, in which either drip proof or totally enclosed motors are interchangeable.

The unit construction enables the pump to be opened for inspection or maintenance without the need to disconnect the pipework or lift the motor. The mere removal of the nuts securing the pump casing permits the motor, complete with the seal housing, to be moved back along the slide



rails on which it is mounted. The impeller and the inside of the pump casing are thus exposed without in any way disturbing the pipes and pipe joints.

Twenty-nine pump sizes, ranging from 1 to 5 in. branch size, provide a comprehensive choice of pump and motor combination. By fitting motors suitable for 50 c/s supply at both 2 pole and 4 pole speeds, a range of duties is available up to 500 g.p.m. and total heads of 180 ft. *Rhodes, Brydon & Youatt Ltd.*, Reddish Engineering Works, Stockport, Cheshire.

EMD 7791 for further information

Static Eliminator

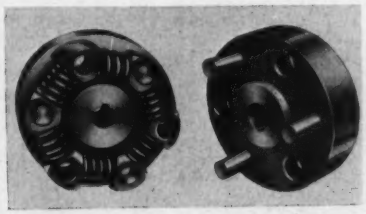
In many processes involving continuous movement there is a continual accumulation of static electricity, which can reach dangerous proportions. An effective method of discharging this is to blow a stream of ionised air over the product concerned. The Simco Aerostat is a long-range static eliminator capable of neutralising materials up to 4 ft. away. It consists of a centrifugal blower incorporating a static-neutraliser head in the air outlet—the ionised air produced there is carried in the air stream to the material to be discharged.

The Aerostats are operated from small power units, and two models are available, one having twice the ionising capacity of the other. For discharging large parts or wide materials, the units may be butted together end to end to create a continuous neutralising field in any width. If neutralisation is required at a distance of 4 ft., low speed of travel is required, but for shorter distances the speed may be increased. *Meech Electric Drives (London) Ltd.*, 150 Clapham Manor Street, London, S.W.4.

EMD 7792 for further information

New Flexible Couplings

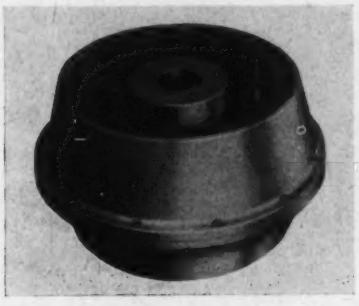
Two new couplings — Cardeflex and Elsi—have recently been introduced. The scope of the all-metal Cardeflex extends



Exploded view of Cardeflex coupling.

from fractional horse-power up to 90,000 h.p. at 330 r.p.m., while Elsi is a safety slipping coupling embodying all the flexible characteristics of Cardeflex.

Where very high speed running is required, Cardeflex is available with steel flanges. Other special designs supplied on request include a coupling incorporating a brake drum; a model for sustaining end



Elsi coupling.

thrust; and another included in a flywheel. Elsi-Hydrostar is another special coupling which has all the features of Elsi plus the advantages of hydraulic de-clutching. *J. H. Fenner & Co. Ltd.*, Marfleet, Hull.

EMD 7793 for further information

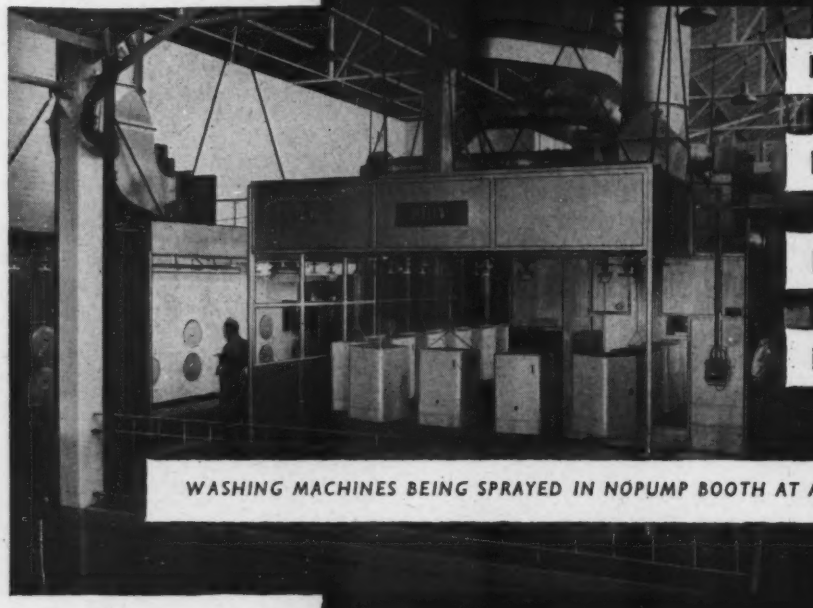
FOR MORE INFORMATION
about any of the products mentioned on these pages, please use the special reply card bound in this issue.

READERS' ADVISORY SERVICE
We shall be pleased to help readers who have difficulty in tracing sources of supply of materials or components.

This is nothing to what goes on inside a

BULLOWS NOPUMP SPRAY BOOTH

In this new type of Water-Wash Spray Booth the exhaust air travels at very high velocity over the water surface entraining water. The air/water mixture, moving through controlled changes of direction, provides the scrubbing action.



NO PUMP

NO FILTERS

NO PIPES

NO NOZZLES

WASHING MACHINES BEING SPRAYED IN NOPUMP BOOTH AT ADA (HALIFAX) LTD.

CUTS MAINTENANCE BY 90%

Longer time between clean-outs

Residues completely broken down and easily handled

Lack of adhesion of deposits

Smooth, easily cleaned surfaces

Low first cost due to simplicity

Occupies minimum space

WRITE FOR FULL DETAILS FROM

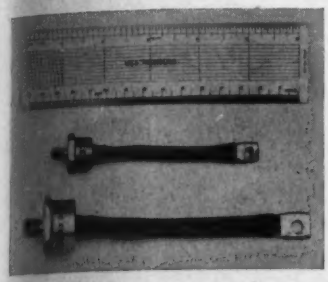
A. BULLOWS & SONS LTD · LONG ST · WALSALL · STAFFS · TEL 27251

DEPOTS AT: 13 SOUTH MOLTON ST., LONDON, W.1. Tel: MAYFAIR 2313
55a BRIDGE ST., MANCHESTER, 3 TEL: BLACKFRIARS 5670
70 GILMOUR ST., GLASGOW, C5 TEL: SOUTH 2383
61-63 DRURY ST., DUBLIN. TEL: DUBLIN 73188/9
BULLOWS (AUST). PTY. LTD., ETHEL AVENUE, BROOKVALE, SYDNEY, AUSTRALIA

WHAT'S NEW IN COMPONENTS

High-voltage Medium-power Silicon Diodes

Two new ranges of high-voltage medium-power silicon diodes are now available. The SxBR8 is rated at 18 amps.,



and may be used at case temperatures of up to 140 deg. C., while the SxBR25 is rated at 30 amps. and may be used at similar case temperatures. Both ranges are freely available in voltage ratings of 100 to 1,500 volts peak, with ten intermediate voltages.

The diodes are hermetically sealed using glass-metal seals and the latest press seal techniques. Mounting is by means of a stud base which also serves as the anode connection. The cathode connection is made by means of an insulated flexible lead through the glass/metal seal. *Westinghouse Brake and Signal Co. Ltd.*, 82 York Way, Kings Cross, London, N.1.

EMD 7794 for further information

Miniature Precision Resistors

Precision wirewound fixed resistors, known as the P type, are now available in fifteen standard sizes, including three miniature printed circuit models. These resistors are wound on bobbins made from mineral-filled epoxy resin, and then enveloped with an optimum amount of the same hot-curing resin. This is claimed to result in a high degree of protection against climatic variation, combined with minimum weight.

Connection is made through axial wire leads or radial lugs, and the contours of the resistor body are specifically planned to provide a long leakage path between terminals or to earth. The anchorage of the terminals is so designed that excessive flexing of the lug or lead cannot destroy the seal.

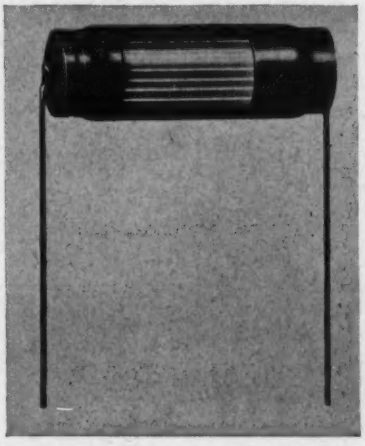
P-type encapsulated resistors have been in use for some years in the U.S.A., as surpassing the requirements of Specifications MIL-R-9444E and MIL-R-93A. *Miniature Electronic Components Ltd.*, The Lye, St. Johns, Woking Surrey.

EMD 7795 for further information

New Photoconductive Cell

A new cadmium sulphide photoconductive cell (NSL-33) for photometric applications, particularly where low light levels and low voltages are available, has been introduced in the U.K. The spectral response of the cell is said to resemble that of the human eye, and the recommended illumination range is from 0·01 to 1,000 foot candles. It is claimed to be 1,000 times more sensitive and also more powerful than selenium cells of equal area which are used in existing exposure meters.

The NSL-33 can be used for television brightness and contrast control; any light measuring device; photometers; exposure meters; and automatic cameras. The temperature coefficient is unusually low for this type of cell, and there is virtually no "dark adaptation" or "light fatigue". The



cell is cylindrical in shape with a curved rectangular window, and is hermetically sealed. It is 1·25 in. long × 0·354 in. dia. *Hird-Brown Ltd.*, 244 Marsland Road, Sale Cheshire.

EMD 7796 for further information

New Wander Plug and Socket

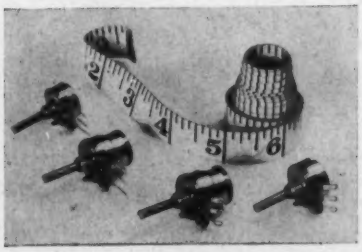
A new Clix miniature wander plug and socket, particularly suited to printed circuit mounting is announced. Socket mounting pin diameter is 0·050 in., conforming to the 0·1 in. module printed circuit technique, and the socket can be mounted on a 0·2 in. centre using the standard nominal 0·050 dia. mounting hole. Overall diameter of the socket body is 0·19 in., pin length is 7/64 in., and body length $\frac{11}{32}$ in.

The overall diameter of the plug is 0·19 in., with a pin diameter of 0·04 in., pin length of $\frac{1}{4}$ in., and body length of $\frac{7}{16}$ in. The metal parts are brass, silver plated, and the insulation is nylon. Standard colours are red or black, but other colours can be supplied to special order. *A.E.I. Radio and Electronic Components Division*, 155 Charing Cross Road, W.C.2.

EMD 7797 for further information

Miniature Carbon Potentiometers

A new range of miniature carbon potentiometers, intended for use in small-size battery radios, has been introduced. Logarithmic and linear types are available with values ranging from 1 K ohm to 500



±20%. The potentiometers can be supplied either with three soldering tags for wire connection or three terminal pins for direct mounting to a printed board. *Mullard Ltd.*, Mullard House, Torrington Place, London, W.C.1.

EMD 7798 for further information

Digitising Discs

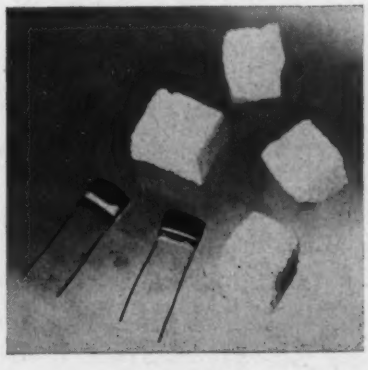
A new range of discs, manufactured photographically, makes it possible to digitise the angular position of a shaft to an accuracy of two parts in a million. The high accuracy of the discs makes possible direct coupling between the shaft and the encoder without the use of gearing, thus eliminating errors due to mechanical wear, backlash, etc. The standard range of encoders will provide from eight to nineteen bits in various codes, including cyclic binary, straight binary, sine-cosine and coded decimal. Built-in transistorised amplifiers on each track enable the outputs from the encoders to be connected directly to the computing equipment. *Rotax Ltd.*, Willesden Junction, London, N.W.10.

EMD 7799 for further information

Polyester Capacitors

The accompanying photograph shows examples from a new range of polyester capacitors intended for use in transistor printed circuits. *Mullard Ltd.*, Mullard House, Torrington Place, London, W.C.1.

EMD 7800 for further information



They ought to! They ought to! People who don't protect the inside of their tanks with Ensecote are robbing themselves. Ensecote protective linings will protect practically anything you can put inside a tank, *any* size tank. They're tasteless, odourless, easy-cleaned, sterilized—and economical to apply. Ensecote protective linings add years to a tank's life.

ENSECOTE *Lithcote* PLASTIC LININGS

For literature and technical advice on linings, and on tank fabrication, write to: NEWTON CHAMBERS & CO. LTD., THORNCLIFFE, SHEFFIELD, ENGLAND

Agents in Belgium, France and Holland: FOURS LECOCQ ET ATELIERS DE TRAZEGNIES REUNIS, S.A., TRAZEGNIES, BELGIUM

WHAT'S NEW IN EQUIPMENT

New High-speed Recorder

The Type R.1 single-channel high-speed recorder is the first to be released from a new range of high-quality direct-writing recording equipment which is being designed to meet the requirements of engineers engaged in industrial and medical research or routine investigation. By using transistors throughout the amplifier and control circuits, a relative wide writing excursion of 5 cm. with high-frequency response has been achieved in an instrument of small size and low weight. Power to drive this instrument is obtained either from a.c. mains or directly from a 12 volt accumulator, the accumulator being recharged by the instrument when connected to the mains.

The moving coil galvanometer is of particularly robust construction, and is completely sealed to prevent ingress of dust or metal particles. A choice of two writing systems is available: (a) hot stylus on heat-sensitive paper, writing in rectilinear co-ordinates; and (b) ink pen on untreated paper writing in curvilinear co-ordinates. Each system can be easily interchanged with the other in a matter of minutes; an ink reservoir is provided with means of sealing to prevent spillage of ink during transit.

Any of six pre-set paper speeds can be selected instantly by means of two lever switches. The speed of the paper is governed by a servo-amplifier which continually corrects the output torque of a d.c. drive motor to provide a final drive accuracy of better than 2%. *Device Sales Ltd.*, 13-15 Broadwater Road, Welwyn Garden City, Herts.

EMD 7801 for further information

High-power Diesel

The National Gas & Oil Engine Co. Ltd. announce the development of a Vee-form version of their well-known 'F' series of diesels. This will extend the range of National 'F' engines, already available from 285 to 1,550 b.h.p., to 3,100 b.h.p. in sixteen-cylinder form, making this one of the most highly powered engines in the world for continuous industrial operation at 600 r.p.m. The FV will be suitable for operation on diesel oil, gas, or as a dual fuel engine, and it is anticipated that it will be available for commercial sale as a proven unit next year.

The new engine will have the same bore and stroke (12 × 15 in.) as the present in-line engine and will incorporate many of its design features, and the well-tried combustion characteristics of the 'F' design will be preserved by the use of the present cylinder head, piston and cylinder liner. Many other parts will also be common to both the in-line and the Vee-form engine, so that users will be able to maintain engines of a wide range of powers from a single stock of interchangeable spares.

A number of advanced techniques have been used in designing the new engine. Photo-elastic stress analysis of the crankcase and cylinder block was carried out on models prior to the construction of full scale twin cylinder prototype engines for development purposes.

Articulated connecting rods will give the new Vee-form engine a compact and economical design. Strain gauge measurements have been obtained from connecting rods of alternative designs in a hydraulically loaded static test rig, and the rods are being tested in the twin cylinder engines to decide the most suitable design from the aspect of cost and reliability. Testing of the prototype under high load conditions will take several months and the final design of the multi-cylinder engine will be influenced by the findings of these tests. *Hawker Siddeley Industries Ltd.*, Duke's Court, Duke Street, St. James's, London, S.W.1.

EMD 7802 for further information

Circuit Tester

The Lavoie Robotester L.A. 303, now available in the U.K., is an automatic tape-programmed measuring instrument. With it any two of 250 circuit points can be selected for measurement of resistance, polarised d.c. or a.c. voltage, insulation resistance and impedance.

The range of voltage measurements can be from 0·5 to 500 volts, and the resistance range is from 1 to 9·99 megohms with selected tolerance of 1, 5, 10 or 20 per cent nominal. Impedances in the range of 50 ohms to 100 K ohms are measured at programmed frequencies of 159 c/s, 1·59 kc/s or 15·9 kc/s. Sixty to 100 tests per minute indicate wiring or assembly failures by flashing light indicators. The results of tests can be recorded with accessory equipment. *Metrix Instruments Ltd.*, 54 Victoria Road, Surbiton, Surrey.

EMD 7803 for further information

New Oscilloscope

The new Solartron CD 1012 is a d.c.-25 Mc/s oscilloscope of high sensitivity, with extensive triggering facilities and a time-base to cover applications ranging from d.c. and low-frequency servo work at one extreme to high-frequency and pulse work at the other. The CD 1012 provides clear, brilliant displays of fast and slow waveforms on its 5-in. dia. c.r.t. operating at 13·5 kV. 0·2 μsec. coaxial cable signal delay allows leading edges of pulses to be displayed. Window size is 10 × 6 cm.

The main d.c.-25 Mc/s amplifier has a sensitivity of 50 mV./cm. to 20V./cm., covered in nine calibrated ranges. A built-in a.c. coupled preamplifier extends the sensitivity (at reduced bandwidth) to 500 μV/cm. in a further six ranges. Y sensitivity is controlled by a frequency-compensated stepped attenuator (1-2-5 switching sequence), with a fine gain control for continuous coverage. Two screen diameters of Y shift are provided and the Y plates are accessible. In the event of the trace being deflected off the screen it is easily returned into view by pressing a "trace locator" button. *Solartron Laboratory Instruments Ltd.*, Cox Lane, Chessington, Surrey.

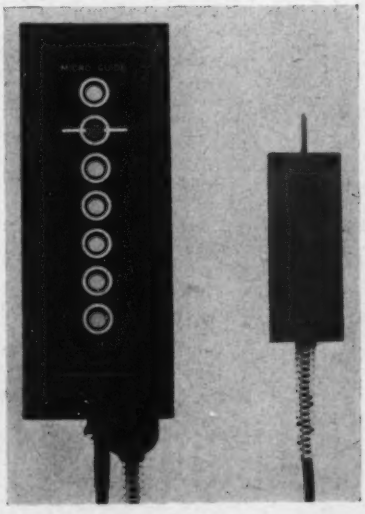
EMD 7804 for further information

Automatic Electrical Gauge

The Parametric Micro-guide consists of an indicator panel and a micro head. The micro head is a compact sealed unit, just over 4 in. long with a projecting gauge lever at one end and a connecting cable from the other. Fixing holes are provided for securing into place on the machine. The gauge lever, when deflected in either of two opposite directions, controls electrically the indicator panel. With a normal setting, full rough cuts may be taken until the lighting of the lowest (green) window indicates arrival within 0·025 in. of the final true size, remaining alight to provide a warning during the advance towards 0·005 in. from final size. At this stage the ultimate advances of each thousandth of inch are represented by the lighting in turn of the amber windows above until true size appears in the red window. An over-run of one thou. beyond this true size causes a blue light to appear above, and an audible warning is heard.

The Micro-guide can be fitted to a variety of machine tools. On a turret lathe a micro head is fitted to the machine in such a position that the usual six pre-set stops will automatically engage the micro head lever instead of the fixed back stop. *Paramatic Development Ltd.*, Canal Street, Derby.

EMD 7805 for further information



Whatever started it, one thing is certain; *combustible materials kept it going.* It's sound sense, then, to investigate the proved qualities of Het Acid. Materials fabricated from polyesters based on Het Acid will not support combustion. Unfed, the fire dies at source.

In addition, Het Acid based resins offer fabricators:

☐ High strength with light weight ☐ Non-deterioration of fire-retarding properties in all climates ☐ Resistance to corrosion and chemical attack ☐ Resistance to temperatures up to 150°C.

HET ACID for self-extinguishing polyesters

POLYESTER RESINS based on Het Acid have already been used to advantage for: roof lighting and decorative translucent panellings; boat construction; chemical plant; housing for motors and electrical equipment; insulating laminates for switch-gear; ductings in aircraft; the manufacture of radomes, and many other applications. Resins based on Het Acid open up exciting possibilities to fabricators in every field of industrial research and development.

These polyesters are made by leading resin manufacturers. We will be pleased to send you complete information on request.

ALBRIGHT & WILSON (Mfg) LTD

SECTION HR1, Organic Chemicals Department
1 Knightsbridge Green, London, S.W.1. KEN 3422

WHAT'S NEW IN THE OFFICE

Self-adhesive Mounting Tissue

Halco-bond can be used for mounting maps, charts, plans, dyeline prints and blueprints, etc. on to rigid materials such as plywood, hardboard, metal and plastic. The self-adhesive tissue itself is supplied with a piece of special backing paper on both surfaces. The backing paper must be removed when the adhesive is applied to the original to be mounted.

In applying the film the original should be laid out face downwards on a clean flat surface. (A drawing board is ideal for this purpose.) A piece of Halco-bond is now cut to the required size, allowing an extra margin on all sides for trimming after application. One of the backing papers is now separated along the narrow side of the sheet and the adhesive surface is applied to the corresponding side of the original. About ½ in. of the tissue should overlap the edge as this is pressed down on to the surface of the drawing board to secure the original.

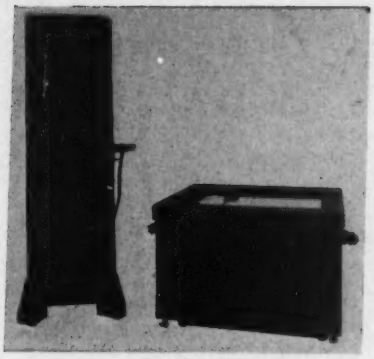
The plywood sheet or other rigid surface is now placed face upwards on the drawing board. About ½ in. of the second backing paper is separated along the narrow side of the original, and the backing paper is placed in contact with the plywood. The original is now carefully registered along the edges of the plywood and the ½ in. adhesive strip carefully smoothed down in contact with the plywood. The original can now be brought into contact with the plywood by using an applicator or ruler and gradually removing the backing paper. *J. Halden & Co. Ltd.*, Rowsley Works, Reddish, near Stockport.

EMD 7806 for further information

Automatic Graph Plotter

Originally developed by Benson-Lehner Corp. in Los Angeles, automatic graph plotters are now being manufactured in the U.K.. These mechanical plotters perform the conversions quickly, accurately and entirely automatically. The object of a plotting machine is to convert a list of numbers into a series of points through which a graph can be drawn. It is completely automatic in operation if the data is presented in a form that can be read mechanically or electronically, such as punched cards, punched tape or magnetic tape.

On the Electroplotter Model 'H', data is entered from punched cards, punched tape or a keyboard. Numbers up to four digits are handled and points are plotted within an area of 30 by 30 in. by a symbol such as a full stop or a star and are positioned to an accuracy of a hundredth of an inch. The unit consists of three major parts: a standard reader for punched card or punched tape; a cabinet containing the control circuits; and the actual plotting table. Paper supply and



take-up reels are situated along opposite edges of the horizontal table; while two bars, arranged at right angle to each other, span the table and carry the plotting head at their intersection.

The Electroplotter Model 'H' can plot any one of 12 symbols and can lay out several different curves simultaneously. It selects the symbol for printing and positions it fully automatically under control of 4-digit numbers read from punched cards or tape; and it deals with about 50 such data points per minute. This plotter can also draw straight lines between consecutive data points, at the rate of about 15 per minute, all positioned to an accuracy of one hundredth of an inch. A smaller machine is also available, the model 'E', but this does not provide drawing facilities. *Benson-Lehner (G.B.) Ltd.*, West Quay Road, Southampton.

EMD 7807 for further information

New Publications and Technical Literature

Thos. W. Ward Ltd.: 164-page illustrated catalogue covering the company's stocks of new, reconditioned and second-hand machinery and machine tools. Albion Works, Sheffield.

EMD 7808

Castrol Industrial Ltd.: 42-page revised edition of the booklet "Transformer and Switch Oils", including chapters dealing with the properties of transformer oil, causes of oil deterioration, the care of transformer oil, and oil purification. Castrol House, Marylebone Road, London, N.W.1.

EMD 7809

Johnson, Matthey & Co. Ltd.: The latest edition of data sheet 1300:487, dealing with Platinax II (cobalt-platinum permanent magnet alloy. This new version includes data on heat-treatment and properties at elevated temperatures. 73-83 Hatton Garden, London, E.C.1.

EMD 7810

Hot Dip Galvanizers Association: *"Hot Galvanizing—the Process and the Product"*, an 8-page booklet describing the hot galvanizing process, and containing notes on: the formation of alloy layers; spangle; corrosion resistance; fabricating; and methods of finishing. 34 Berkeley Square, London, W.1.

EMD 7811

Scott Bader & Co. Ltd.: 1961 edition of the firm's well-produced *Polyester Handbook* (129 pages). Wollaston, Wellingborough, Northants.

EMD 7812

Crofts (Engineers) Ltd.: 19-page illustrated brochure on the company's range of geared motors and reduction gears. Bradford 3, Yorks.

EMD 7813

Stewarts and Lloyds Ltd.: Well-illustrated 44-page brochure describing the Tollcross Steel Foundry, at Glasgow. There is also a section setting out British Standard steel specifications and American equivalents, and another dealing with the company's special-purpose irons and steels. Brook House, Upper Brook Street, London, W.1.

EMD 7814

Cambridge Instrument Co. Ltd.: Two leaflets: List 281/2, describing the Cambridge Magnetic Oxygen Meters, which have been developed for the determination of oxygen concentrations using methods based on the high paramagnetic susceptibility of the gas; and List 325, dealing with the firm's standard range of rare- and base-metal thermocouples for temperatures up to 1,500 deg. C. 13 Grosvenor Place, London, S.W.1.

EMD 7815

Hassett & Harper Ltd.: *Cabinets for Electronic Equipment*, a well-illustrated 16-page brochure. Regent Place, Birmingham 1.

EMD 7816

Parkinson Cowan Measurement: *"Pumping"*, a 12-page illustrated brochure on the firm's range of Rotoplunge pumps. The Shoflo sight flow indicator is also described. 7-17 Fitzalan Street, London, S.E.11.

EMD 7817

Bardahl Products Ltd.: 11-page booklet describing the use of oil additives for reducing the cost of power consumption and plant maintenance in industrial applications. *Print Supervision Ltd.*, 8 Buckingham Street, London, W.C.2.

EMD 7818

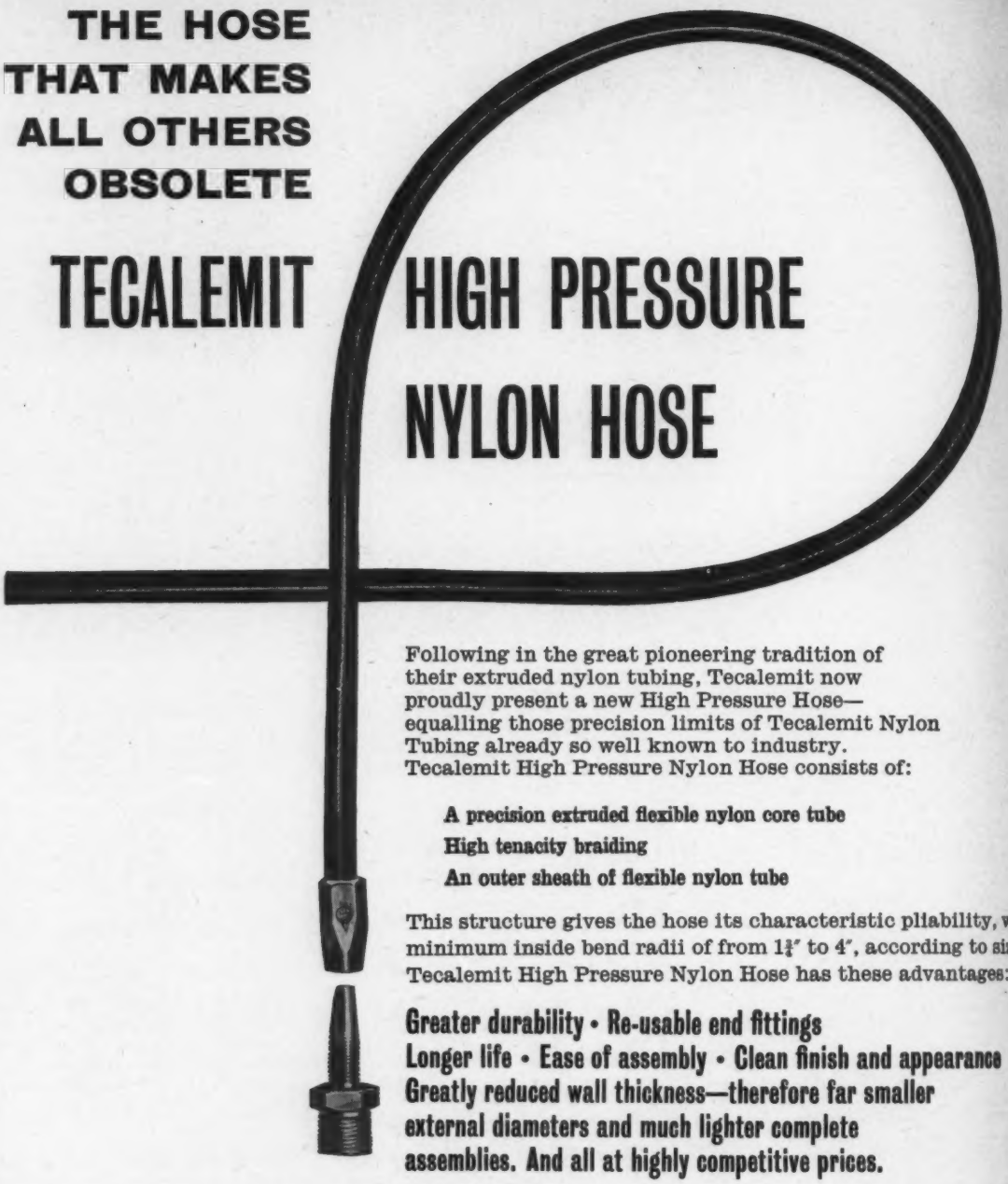
Polypenco Ltd.: Three leaflets, dealing with: Fluorosint, a reinforced t.f.e. resin available in moulded parts; Nilatron G.S., a molybdenum disulphide filled Nylon 66 available as stock shapes or moulding compound; and Nylaflow, a flexible high-pressure hose of all-bonded construction with nylon inner core, available in long continuous lengths with a range of re-usable end fittings. 68-70 Tewin Road, Welwyn Garden City, Herts.

EMD 7819

EMD 7686 for further information

THE HOSE THAT MAKES ALL OTHERS OBSOLETE

TECALEMIT HIGH PRESSURE NYLON HOSE



Following in the great pioneering tradition of their extruded nylon tubing, Tecalemit now proudly present a new High Pressure Hose—equalling those precision limits of Tecalemit Nylon Tubing already so well known to industry. Tecalemit High Pressure Nylon Hose consists of:

A precision extruded flexible nylon core tube

High tenacity braiding

An outer sheath of flexible nylon tube

This structure gives the hose its characteristic pliability, with minimum inside bend radii of from 1¾" to 4", according to size. Tecalemit High Pressure Nylon Hose has these advantages:

Greater durability • Re-usable end fittings Longer life • Ease of assembly • Clean finish and appearance Greatly reduced wall thickness—therefore far smaller external diameters and much lighter complete assemblies. And all at highly competitive prices.

If you wish to substantiate these claims, Tecalemit will provide sample standard lengths of hose assembled with common forms of coupling, so that test rigs can be undertaken. Tecalemit High Pressure Hose is supplied in five sizes, ⅛", 5/16", ¼", ⅜" and ½" internal diameter, to meet the needs of industry for hydraulic and pneumatic systems. Write for full technical details of Tecalemit High Pressure Nylon Hoses and their use on hydraulic and pneumatic systems for:—

Agricultural Machinery · Earth moving Plant Mechanical Handling Plant · Machine Tools

TECALEMIT LIMITED (SALES EM) · PLYMOUTH · DEVON 1700

NEWS OF INDUSTRY

A.c. Alternator for Bus

A new contract from the Glasgow Corporation calls for a fleet of 150 rear-engined Atlantean double-deck bus chassis to be manufactured by *Leyland Motors Ltd.* to special requirements. One of the special fitments is an a.c. alternator instead of the conventional dynamo.

The main advantage of this type of alternator is its large generation of electricity at low revolutions. It can charge the batteries even when the engine is idling. Because of this, the storage capacity of the battery does not need to be as great as for a dynamo system, and a smaller, lighter and less costly battery can be used. In practice, the battery need only be used for starting the bus or providing current for lighting when the engine is not running. A further advantage of the a.c. system is the ability to use fluorescent lighting should this be required, as for example in the Leyland Worldmaster buses destined for use in Brisbane, Australia. These are fitted with Simms a.c. generating equipment, and fluorescent lighting which is stated to be three times brighter than tungsten filament lighting.

Traffic Control Barrier

A traffic control barrier made by *R. B. Pullin & Co. Ltd.*, designed primarily for controlling vehicular and pedestrian traffic on factory roads, is made of a light tubular alloy and can be fabricated with an arm of any length of up to 16 ft. 4 in. It is raised or lowered by an electric motor, and is supported in a substantial main frame. The arm of the barrier carries large circular signs bearing the word Stop.

When several barriers are being used in conjunction, they can be remotely controlled from a panel which provides automatic interlocking. When barriers are out of sight of the operator, a system of warning lights can be incorporated.

The barrier arm is hung on a frame which in turn is mounted on a stout post for sinking on site to a depth of 18 in. The barrier is powered by a ¼-h.p. geared motor, the ratio of which has recently been reduced from 7:1 to 4:1. This new ratio helps to ensure that there is no vibration when the arm reaches its upper or lower limits. Motor and gearbox are totally enclosed, and the barrier is driven from the gearbox by means of a chain and sprocket via a friction clutch to a chain which is bolted to the main trunnion. Clutch torque is set so that it is only just sufficient to raise the barrier—this prevents damage to the gearbox if the barrier should be forced by an external impact between its limits of travel.

Switches cut off the motor when the barrier reaches its last inch of travel. This ensures that the momentum of the barrier is absorbed in slipping the clutch, and that there is no heavy impact on the rubber stop pads. To prevent corrosion, all structural steel parts are treated with rust preventive, and screws, nuts, etc., are cadmium plated.

Wood Research

The first phase of major investigations into the qualities of home-grown softwoods has been completed by the *D.S.I.R. Forest Products Research Laboratory*, and summarised in the annual report. They cover a wide range of studies on Sitka spruce and one objective of the spruce investigations is to determine the effect of site factors on the properties of the wood.

Experimental work on the influence of generator frequency on glue setting rates is now at an advanced stage. With rapid setting techniques the adhesive becomes very hot before it cures, and the accompanying drop in viscosity allows absorption by the wood, resulting in a starved joint. This can be overcome by altering the viscosity characteristics of the adhesive by adding flour to the glue mix before use. During the investigation it was found that an addition of 10 per cent of flour was sufficient to bring the strength of radio-frequency set joints up to or even above that of similar cold set material. In joints cured by transverse heating neither the generator frequency nor the setting time affect the seven-days strength, but the moisture content of the wood can become important. This investigation shows, however, that the electrical constants of the wood glue composite must change rapidly with frequency over the range 5 to 25 mc/s.

Research on home-grown timber has become an important part of the Laboratory's programme.

Automatic Reading

Among the various Solartron instruments and specialised equipment exhibited and demonstrated at the opening of the new headquarters of the *Solartron Electronic Group Ltd.* was the E.R.A. or Electronics Reading Automation which reads printed information and translates it automatically into machine language at a speed of up to 300 characters per second with an accuracy considerably greater than that of manual methods. E.R.A. accepts information from such simple traditional sources as cash registers and adding or listing machines and needs neither special inks nor special methods of printing. The output from it can be fed to any standard output processing equipment, such as card punches, paper tape punches, magnetic tape units, or computers, so that E.R.A. can be used in any commercial data processing system.

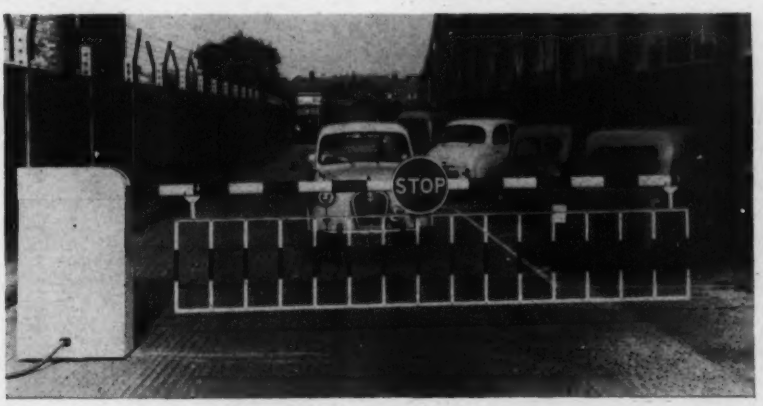
Proving a Design

Tests at *A. V. Roe and Co. Ltd.* to prove the design and structural strength of the Avro 748 feeder line aircraft began with structural details and progressed to the testing of a complete fuselage. In every case, the ultimate design load was exceeded without structural failure. Initial tests established the strength of fuselage formers and floor beams when subjected to the severe loadings resulting from a crash case. Later, a section of the wing, including leading and trailing edges, was tested to demonstrate the strength of a typical wing rib both before and after the rib had been artificially damaged. The latter case is an aspect of fail-safe testing.

A localised structural area, represented by part of the aircraft fuselage complete with wings and tailplane was subjected to loadings simulating all of the most severe conditions encountered during take-off, flight and landing. Over 1,200 strain gauges were attached to the specimen and the results from these were recorded automatically.

Loads were applied to the structure by hydraulic jacks through a series of linkages designed to spread the load over the whole wing structure to give an accurate representation of flight conditions. This specimen was also constructed with one of the integral fuel tanks sealed in the wing and loads were applied with this tank in the full-fuel condition.

Concurrently with the structural test programmes, a schedule of fatigue tests has also been in progress. A complete cabin structure has been immersed in a new water pressure test tank, and pressurised to a cabin differential of 12.1 p.s.i., which is considerably more than twice the working pressure as required by the Airworthiness authorities. During the test schedule, the fuselage withstood over 10,000 pressurisation cycles



New Diesels

A new addition has been made by *Leyland Motors Ltd.* to the Power-Plus range of automotive diesel engines. It is the 0·370 unit with a bore and stroke of 4·07 in. × 4·75 in. developing a gross h.p. of 115 b.h.p. at 2,400 r.p.m. and a net installed h.p. of 110 b.h.p. at the same speed. Maximum net torque is 272 lb./ft. at 1,600 r.p.m. This new engine is the fourth in the Leyland Power-Plus series, and in their development the thermal efficiency has been raised to an entirely new level of over 40 per cent. Fuel consumption has also been reduced.

Leyland's also announce the completion of an order which provided engines for sea-wading tractors for the army. The tractor, known as the 75A Dual Steer, is the result of close co-operation between *Michigan (Great Britain) Ltd.* and the army authorities, who wanted a tractor for military use which was still almost identical to the commercial type. The tractor can be driven in either direction with the driver facing the direction of travel; dig a trench with a backhoe; act as a side-shifting fork-lift vehicle, and as a crane, the latter unit being interchangeable with the bucket. It is capable of maintaining a 20 m.p.h. speed in convoy and has two tow hooks fitted front and rear, complete with breakaway air couplings for trailer brake connections. One of the tractor's prime functions must be its ability to wade into the sea to unload landing craft, or to ford shallow rivers. For these purposes it is possible to waterproof the Dual Steer for a wading depth of 6 ft. 6 in.

A New Three-pass Boiler

Richardsons Westgarth (Hartlepool) Ltd., have recently developed an entirely new design of three-pass wet back boiler known as the Maxecon. The basic feature of the new design, a submerged combustion chamber, follows a well established practice. Advantage has also been taken of modern welding techniques to streamline the design while maintaining maximum reliability. The special shape of the combustion chambers enables cross stays to be eliminated and a third pass section inserted, which gives high efficiency without the use of an economiser. Another feature is easy access for internal examination. The whole of the surface in contact with water or steam can be examined from inside the boiler.

The top row of tubes in the third pass is arranged in line with the tops of the combustion chambers, thus making the most efficient use of the space available in the boiler shell below the water line. This provides adequate water coverage to protect the heating surfaces while still retaining a large steam space and height above water level to ensure good steam purity.

The elimination of combustion chamber brickwork not only cuts out a potential source of high maintenance cost, but the heat loss due to radiation is very much reduced and the flue connection to the chimney stack greatly simplified.

New Films

Two new films are available from the *Central Film Library*: *An Introduction to Comminution*, in colour and running for 32 min. (16 mm.); and *The Grievance*, describing the machinery for dealing with workers grievances as laid down under a Canadian labour contract.

Three colour films on various aspects of broaching, made by Lapointe Machine Co. of Hudson, Canada, have been redubbed with an English commentary for *Lapointe Machine Tool Co. Ltd.*, of Watford, Herts. The films are: *Precision Broaching for Production and Profit* (40 min.); *Texas Tower* (20 min.), the story of a special giant machine with twenty broaching stations; and *Helicopter Spar Broaching* (20 min.), showing the speed and accuracy with which the interior profile of a helicopter spar blade can be finished by using a broaching operation.

This filter is 100% efficient—nothing passes through it !

Giant Plastics Container

The above illustration shows a 6,600-gallon capacity glass fibre reinforced polyester tank fabricated by Deutsche Steinzeugwarenfabrik. The U.K. agents for the company are *Anderman & Co. Ltd.*, of London.

Meetings and Exhibitions

The Plastics Institute is organising a series of lectures on plastics at the City of London College, Moorgate, to start on October 2.

The Hydraulic Plant and Machinery Group of *The Institution of Mechanical Engineers* are holding a conference on November 29 and 30 on Oil Hydraulic Power Transmission and Control.

The first annual lecture of the British Conference on Automation and Computation will be given by Dr. D. G. Christopherson, on "Mathematics — Friend or Foe?", at *The Institution of Electrical Engineers* on September 27.

The Iron and Steel Institute is to hold its Autumn General Meeting from November 29 to 30. The title of the symposium that forms the technical session is "The Future of Ironmaking in the Blast furnace". Papers for the four sessions have been contributed by experts from Belgium, France, the U.K. and the U.S.A.

A special series of evening lectures on Oil Hydraulics and their Applications has been arranged at the *Borough Polytechnic*, commencing on October 19.

Also at the Borough are two special lecture courses on the "Technique of Technical Writing" and "Effective Speaking". The former will commence on October 20 and the latter on October 9.

EUTECTIC WELDING ALLOYS COMPANY LTD.

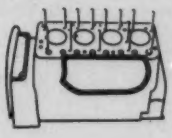
PRODUCT CHECK LIST

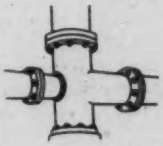
Engineering Materials and Design

DATA SHEET MFG/1—P

EMD 7687 for further information

JOINT DESIGN	ALLOY No.	APPLICATION CHARACTERISTICS	BONDING °C	U.T.S. (t.s.i.)	BHN	DIAMETERS AVAILABLE
CAST IRON & MALLEABLE						
	15	For filling and sealing fine cracks and porous defects.	230	1,500 (p.s.i.)	—	$\frac{1}{16}$
	140 FC	Strong dense machinable deposit with colour match.	800	20	300	$\frac{1}{8}$, $\frac{5}{32}$, $\frac{1}{4}$
	141	General-purpose alloy ideal for repairing thin sections.	800	17	260	$\frac{1}{8}$, $\frac{5}{32}$, $\frac{1}{4}$
	2—24	For all position work where maximum machinability is required.	E	15	150	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{5}{16}$
	25	Applications on spheroidal graphite, cast iron and steel, colour match and machinable.	E	25	170	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{5}{16}$
	27	Produces dense, porosity-free non-machinable deposits.	E	19	—	$\frac{1}{8}$, $\frac{5}{32}$
	Quenchweld	New three-step process for repairing large castings.	E	25	—	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{5}{16}$
	16 FC	High-strength alloy ideal for fabrication of thin-wall tubular structures.	750—800	46	160	$\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{16}$, $\frac{1}{4}$
	1600	Silver bearing alloy for dissimilar metal and thin-gauge joints.	700	24	165	$\frac{1}{16}$, $\frac{3}{32}$
	Steeltectic	All-position Eutectrode giving non-stop deposition on light- and heavy-gauge steel.	E	30	150	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$
	Handomatic	Contact Eutectrode giving smooth porosity-free ductile deposit.	E	30	150	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$
	66	For problem steels high in sulphur, phosphorus, etc.	E	36	150	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{5}{16}$
	71	Cr-Mo electrode; high tensile strength, elongation and ductility plus creep resistance.	E	44	350	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{5}{16}$
	680	For wear, impact, heat- and corrosion-resistant welds and overlays on high alloy steels. (austenitic).	E	50	220	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{5}{16}$
	Unimatic 6000	Excellent for poor fit joints and dissimilar gauges, and rapid fabrication of mild steel plates at low amps.	E	30	150	$\frac{1}{8}$
STAINLESS STEEL						
	157	Solder-type alloy; good corrosion resistance, ductility and conductivity.	200—260	6	—	$\frac{1}{16}$, $\frac{1}{8}$ coil
	157 BN	Non-corrosive neutral flux core ensures totally inert non-conductive fungus-free residues.	220	6	—	$\frac{1}{16}$, $\frac{1}{8}$, coil
NICKEL & NICKEL ALLOYS						
	222	For joining nickel, Inconel, Monel, and as a corrosion-resistant overlay.	E	38	—	$\frac{1}{8}$
COPPER, BRASS & BRONZE						
	18 FC	High-strength alloy ideal for galvanised materials without damage to zinc coating.	750	30	125	$\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{16}$
	146 FC	Non-fuming alloy giving uniform deposits.	750	29	105	$\frac{3}{32}$, $\frac{5}{32}$, $\frac{1}{8}$
	180	Thin-flowing alloy with good corrosion resistance and electrical conductivity.	650	18	125	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$
	183 FC	For use on deoxidised or electrolytic copper; good colour match and electrical conductivity.	1,063	14	—	$\frac{1}{8}$ $\frac{1}{4}$
	185 FC	A high-strength copper-base alloy with good ductility and low coefficient of friction. Work hardens.	600	35	110/220	$\frac{1}{8}$, $\frac{5}{32}$, $\frac{1}{4}$
	189	Bead-forming alloy with colour match to red and phosphorus bronze, and equal corrosion resistance.	825	21	—	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{5}{16}$
	800	Versatile alloy for use on copper and copper alloys where silver solders would normally be used.	650	27	190	$\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$
	1020 FC	Flux-coated silver-brazing type alloy, cadmium-free; high fluidity and good capillary flow.	538—565	21	—	—
	1030 FC	Companion to 1020 FC; designed for poor fitting joints. Has a wide plastic range, and is bead forming.	565—620	22	—	
	1601	Thin-flowing silver-type alloy giving ductile leak-proof joints.	650	27	160	$\frac{3}{32}$, $\frac{5}{32}$
	1800	Recommended for dissimilar metal joints where thin-flowing deposits give smooth fillets.	625	25	95	$\frac{1}{16}$, $\frac{3}{32}$
	1801	Ideal for light-gauge metals; has ductility and medium plastic range; colour matches brass.	630	20	95	$\frac{1}{16}$, $\frac{3}{32}$
	1802	Exceptional capillary action and penetration on large and complicated assemblies.	625	20	95	$\frac{1}{16}$, $\frac{3}{32}$
	AC 280 DC	Excellent colour match to bronze; spatter-free dense deposits; fully machinable.	E	20	100	$\frac{1}{8}$, $\frac{5}{32}$
	30 AC 300 DC	Deposits are dense, porosity-free high-purity copper.	E	14	80	$\frac{1}{8}$, $\frac{5}{32}$
	1850 AC 1851 DC	Rapid deposition with minimum heat input; smooth, porosity-free, copper-base alloy. Work hardens.	E	40	130-140	$\frac{1}{8}$, $\frac{5}{32}$





ALUMINIUM & MAGNESIUM

	19	Self-fluxing zinc-base alloy containing aluminium. Deposits are harder than aluminium.	320—340	5	—	1/8, 3/16, 1/4
	21	Rapid solidification; is excellent for bevelled butt joints. Can be used as bead-forming or thin-flowing alloy.	550	13	—	1/16, 3/32, 1/8, 3/16, 1/4
	22	Silicon-free alloy with high-purity aluminium deposit, suitable for anodising.	650	4	55—65	1/16, 3/32, 1/8, 3/16
	51	For joining aluminium to dissimilar metals, e.g., copper, brass and steel. Close colour match.	200—260	3	—	1/16, 3/32, 1/8 coil
	190	Zinc-free alloy; good capillary flow and colour match to aluminium.	530	12	55—65	1/16, 1/8, 3/16
	210	Bead-forming alloy giving dense machinable deposits; colour match, corrosion resistance, and rate of expansion matching base metal.	550	13	55—65	1/8, 3/16, 1/4
	1900	Bead or thin-flowing alloy with colour match and similar properties to magnesium.	550	15	55—65	1/8, 3/16
	1909	Lead-free solder-type alloy which will bond and weld below the temperature at which aluminium alloys are affected.	157	4	—	1/8, 3/16
	2101	High-silicon aluminium Eutectrode giving high-strength deposit free of porosity.	E	15	55—65	1/8, 3/16, 1/4

ZINC DIE CASTINGS

	196	Bead-forming zinc-base alloy with colour match.	275	6	—	1/8, 3/16, 1/4

SOLDER-TYPE ALLOYS

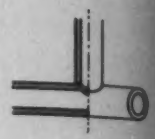
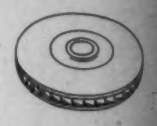
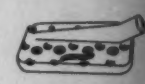
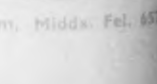
	155	Good wetting and flowing properties. Corrosion resistance better than normal solders.	380	7	—	3/16, 1/4
	199	Thin-flowing alloy; low melting-point minimises distortion, and gives liquid-tight joints.	170—200	2—3	—	3/16, 1/4

PASTE-TYPE ALLOYS

	Tinweld i ii iii iv	Alloy/flux paste suitable for application by brush, spatula or dipping. Flux residues are water soluble.	200/220	2—7	4 types available	jars
	Silweld	Alloy/flux paste for joining ferrous, nickel and copper-base metals.	625	55	—	jars
	Autochemic 990	Paste compound which creates a chemical chain reaction finishing in metallic reduction.(aluminiums)	400	9	—	jars

SPECIAL PRODUCTS

	Cuttrode 1 and 2	Gives high-speed cutting in all positions, requiring no oxygen or gas. Cuttrode 2 is designed for use *under water*.	E	—	—	1/8, 5/32, 3/16
	Chamfertrode	Used to gouge out defective, unwanted or fatigued metal; requires no oxygen.	E	—	—	5/32, 1/4, 5/16
	Eucleen	Removes heat discolouration oxides without over-etching the base metal.	—	—	—	jars
	Form-a-jig	Heat-resisting plastic compound for holding parts in position prior to joining.	—	—	—	tins

OVERLAYS & HARD FACING

	2	For steel, manganese steel and cast iron subject to abrasion, wear and slight impact.	E	—	460-520	1/8, 5/32, 3/16
	2B	Used on all ferrous metals subjected to severe impact and mild corrosion.	E	—	223-235	5/32, 3/16, 1/4
	4	An iron-base alloy with nickel and manganese. A tough, smooth, ductile metal which will work harden.	E	—	260	1/8, 5/32, 3/16, 1/4
	5HSS	Deposits high quality high speed steel	fusion	—	58/62 RC	5/32, 1/8, 5/32
	6HSS	Gives minimum dilution and freedom from porosity with low amperage. Deposits high speed steel.	E	—	58/62 RC	5/32, 1/8, 5/32
	9	Non-magnetic and non-heat treatable; will accept high polish; resists pitting and galling.	950/1,050	—	550-650	3/16
	10	Will resist the severest abrasive wear. Recommended for high hardness at elevated temperatures.	E	—	63/68 RC	1/8, 5/32
	11	For torch application similar to 12	fusion	—	carbides	5/32 —
	12	Contains tungsten carbide in a steel matrix; for abrasive overlays.	E	—	carbides	3/16
	61	Passes can be made without slag chipping; ideal for use in confined areas.	E	—	502	1/8, 3/16
	88	Matrix alloy is tough and durable under impact, and allows relocation of carbide particles without dislodgement. For oil drills, star drills, etc.	750 matrix	185/375	185 (matrix)	1/8, 3/16, 1/4, 5/16
	172	Gives utmost resistance to wear, high temperatures, impact, corrosion and frictional wear.	E	—	427-545	3/16, 5/32, 3/16